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Scheduled Civil Aircraft Emission Inventories for 1999: Database Development and Analysis

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Glossary

AEAP	Atmospheric Effects of Aviation Project (NASA)
ANCAT	Abatement of Nuisances Caused by Air Transport
ASK	Available seat kilometer (the number of seats an airline provides times the number of kilometers they are flown)
BMAP	Boeing Mission Analysis Process
CAEP	ICAO Committee on Aviation Environmental Protection
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOE	United States Department of Energy
DOT	United States Department of Transportation
DLR	Deutsches Zentrum fuer Luft- und Raumfahrt
EI(CO)	Emission Index (grams CO/kg fuel burn)
EI(HC)	Emission Index (grams hydrocarbon/kg fuel burn)
EI(NOx)	Emission Index (grams NOx (as NO_2)/kg fuel burn)
FRT	Freighter designator in schedule data
GAEC	Global Atmospheric Emissions Code
GE	General Electric
HC	Unburned hydrocarbons
H_2O	Water
ICAO	International Civil Aviation Organization
kg	kilogram
lb	pound
Load Factor	Percentage of an airplane's seat capacity occupied by passengers on a given flight
LTO cycle	Landing takeoff cycle
M	Mach number
MTOW	Maximum takeoff weight
NASA	National Aeronautics and Space Administration
NOx	Oxides of nitrogen (NO + NO_2) in units of gram equivalent NO_2
OAG	Official Airline Guide
OEW	Operating Empty Weight
P&W	Pratt & Whitney
PAX	passengers
SO_2	Sulfur dioxide
TOGW	Takeoff gross weight
US	United States
3-D	Three dimensional

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Executive Summary

This report describes the development of three-dimensional inventories of aircraft fuel burned and emissions (NOx, CO, and hydrocarbons) from scheduled air traffic for each month of 1999. The data are on a 1° latitude x 1° longitude x 1 km altitude grid. The data files were delivered to NASA electronically. These emission inventories were developed for the NASA Ultra Efficient Engine Technology (UEET) Program under contract NAS1-20341, Task Assignment 19. They will be available for use by atmospheric scientists conducting modeling studies on the atmospheric effects of aviation, including the NASA Global Modeling Initiative (GMI).

Emissions produced by the world's entire aircraft fleet come from scheduled, military, charter and general aviation air traffic. In this report, we present only the results and methodology used for the calculation of emissions from scheduled air traffic which includes turboprops, passenger jets, and jet cargo aircraft.

Global fuel use for 1999 by scheduled air traffic was calculated to be 1.28×10^{11} kilograms. Global NOx emissions by scheduled air traffic in 1999 were calculated to be 1.69×10^{9} kilograms (as NO_2). Calculated global emissions show a seasonal variation, peaking in August with a minimum in February. Emissions for the month of December 1999 were closest to global annual average emissions, although emissions for May (the month typically used as an 'average' month in past NASA inventory studies) were within 1 percent of the global annual average.

A trend analysis for emissions and fuel burned was performed using the results of this current work and previously published emission inventories and scenarios. This analysis showed an increase in the absolute amount of fuel burned, distance traveled, NOx, and CO emissions produced by the scheduled fleet between 1992 and 1999 and a decrease in the absolute amount of hydrocarbon emissions produced. Calculated global fuel use increased by 33% and NOx emissions increased by 35% between 1992 and 1999. The analysis

also showed that scheduled fleet fuel burned and NOx emissions normalized by available seat kilometers decreased between 1992 and 2015.

The methodology used to extract and process air traffic data from the Official Airline Guide was changed from that used to calculate previous scheduled fleet inventories for 1976, 1984 and 1992. To quantify the effects of the methodology changes, an emission inventory for August 1992 was recalculated using the new methodology. Comparisons between the previously published and new August 1992 inventories show good agreement for global fuel burned and NOx totals. For CO and hydrocarbons, the global totals increased by 20 percent and 18 percent respectively with the use of the new methodology. Much of this difference arises from changes in the selection of combustor types for certain engines in the fleet. Hydrocarbon and CO emissions levels for many older technology engines can vary widely depending on the combustor used in the engine.

To improve the accuracy of global emissions calculations for freighters, United States Department of Transportation Form T-100 data was used to determine typical payloads for freighter aircraft. This information was then used to model freighter aircraft more accurately in the inventory calculations by using more realistic payloads.

To assess the effect of the different freighter payload assumptions, results were compared with previous inventory calculations done using 70 percent passenger payload for all aircraft. This comparison showed that improved freighter payload assumptions increased total global fuel burned by 0.6 percent and increased total global NOx by 1.5 percent for August 1999. These increases are relatively small and will not significantly change trends for fuel use or NOx created using the published inventories for 1976, 1984, and 1992.

In order to evaluate the 1999 scheduled aircraft fleet global emission inventory calculations, comparisons were made with aviation fuel use and traffic data reported on the U.S. Department of Transportation (DOT) Form 41 by US air carriers. In general, emission inventory calculations of departures and distance traveled for 1999 compared well (within 5 percent) with the DOT Form 41 data for the ten largest passenger carriers that reported fuel use and traffic data to the DOT. In contrast, for the four largest cargo carriers reporting to the DOT, calculated departures and distance traveled were significantly less than those reported. It appears that the OAG flight schedule data do not contain a complete listing of cargo flights.

For the passenger carriers in the DOT Form 41 data comparison, the emission inventory calculations consistently under-predicted fleet fuel burned. The magnitude of these under-predictions varied depending on the carrier being considered. For the ten largest air carriers reporting data to the DOT, the total fuel burn was under-predicted by 21 percent. This result is likely due to the simplifying assumptions used in the development of the global inventory, including our inability to consider air traffic control delays/diversions, weather/wind factors, more realistic routing, less than optimum aircraft/engine performance and actual aircraft operating weights.

1. Introduction

The NASA Ultra Efficient Engine Technology (UEET) program has been initiated to promote the development of fuel efficient and low NOx emissions jet engines for the future and to evaluate the effects of aircraft emissions on the atmosphere and human health. The work described herein was done in support of the UEET program Environmental Impact Assessment Element (WBS 1.2) which includes atmospheric modeling, health risk assessment, and emission characterization work. The creation of global emission inventories for the scheduled aircraft fleet as a function of altitude and geographical position (referred to as "3-D emission scenarios") is an important component of the atmospheric modeling portion of this element. These scenarios are used as the input to chemical transport models to evaluate the effect of aircraft emissions: how long they persist in the atmosphere, how much they perturb the chemistry or microphysics of the upper troposphere, and how they compare with other sources of NOx, water, soot, and condensation nuclei in the upper troposphere.

In previous NASA studies funded under the High Speed Research and Advanced Subsonic Technology programs, we have developed 3-D emission scenarios for aircraft fleets for 1976, 1984 and 1992 (Baughcum, *et al.,* 1996a and 1996b), and have projected 3-D emission scenarios of both subsonic and supersonic traffic for 2015 (Baughcum, *et al.*, 1998; Baughcum and Henderson, 1998). ANCAT and DLR have also published historical 3-D emission inventories and projections for 2015 (Schmitt and Brunner, 1997; Gardner, 1998). The emission scenario work of NASA, ANCAT and DLR has been compared and contrasted in the *Intergovernmental Panel on Climate Change Special Report on Aviation and the Global Atmosphere* (Henderson, *et al.*, 1999).

The NASA-funded work as well as that of ANCAT and DLR has used a "bottoms-up" approach in which aircraft schedules are obtained or estimated and the aircraft/engine combinations in these schedules are identified. Detailed calculations of fuel burned and emissions are then made along each flight path and the results are distributed over a 3-dimensional global grid space.

Emissions produced by the world's entire aircraft fleet come from scheduled, military, charter and general aviation air traffic. In this report, we present the results and methodology used for the calculation of emissions from scheduled air traffic, including turboprops, passenger jets, and jet cargo aircraft. In 1992, fuel usage for scheduled air traffic accounted for approximately 68% of the fuel usage of the entire aircraft fleet. The scheduled air traffic inventories presented in this report are calculated using the Official Airline Guide (OAG) as the source of scheduled flight data. The OAG accurately accounts for scheduled passenger flights in most regions of the world but it is unclear to what extent it covers cargo flights and flights within China and the former Soviet Union.

This report documents an emission inventory for only the 1999 scheduled aircraft fleet. In order for a complete emission inventory for the world's entire 1999 aircraft fleet to be created, the 3-D scheduled inventory documented in this work would need to be combined with 1999 3-D inventories of the military, charter and general aviation components of the world's fleet. Such inventories were developed earlier for 1976, 1984, 1992 and 2015 (Landau, *et al.*; 1994, Metwally, 1995; Mortlock and Van Alstyne, 1998). In addition, 3-D inventory calculations for year 1999 flights within the former Soviet Union and People's Republic of China not included in the OAG schedule would have to be included if it is determined that the OAG schedule is incomplete for these regions. As of the writing of this report, these additional inventories have not yet been developed for 1999.

To calculate scheduled aircraft fleet inventories, flight schedule data (number of departures for each city pair along with airplane and engine type) are combined with performance and emissions data to calculate fuel burned, oxides of nitrogen (NOx), carbon monoxide (CO), and total hydrocarbons (HC) on a 1° longitude x 1° latitude x 1 kilometer altitude grid. The results for all the different routes and airplane/engine combinations are then summed to produce the total inventory. The details of this process are described in Section 2 of this report.

Results of the 1999 scheduled aircraft fleet emission inventory calculations are analyzed and discussed in Section 3 of this report. The methodology used to create this inventory was changed in a number of ways from that which was used to calculate previously published NASA scheduled aircraft emission inventories. In order to assess the effects on inventory results of changes made to the calculation methodology, an emission inventory for August 1992 was calculated using the same methodology used to calculate the 1999 scheduled inventory. The results of this calculation were then compared to results of the previously published NASA August 1992 inventory calculations (Baughcum, *et al.*, 1996a). This comparison is documented in Section 2.5 of this report. The calculation of the August 1992 inventory using the current methodology is also utilized in Section 3.4 of this report to develop a self-consistent trend analysis of fuel use and emissions.

In the current work, improved modeling of freighter aircraft performance was utilized to improve the overall accuracy of global emissions calculations. A discussion of these improvements is presented in Section 2.3.3 and results of their implementation are presented in Section 3.5.

The work described in this report was conducted under NASA Contract NAS1-20341, Task 19. The NASA Glenn Research Center Task Manager was Chowen C. Wey.

The principal investigator was Steven L. Baughcum. Donald J. Sutkus extracted aircraft departure data from the Official Airline Guide and assigned engines to aircraft types listed in the schedule using the Boeing proprietary computer code "The Emissions Desktop Flight Schedule Creation Module" (TED/FSCM). Donald J. Sutkus also calculated the 3-dimensional aircraft emission inventories using the Boeing proprietary Global Aircraft Emissions Code (GAEC). Douglas P. DuBois provided guidance on the selection of appropriate performance aircraft and emissions engines characteristics to use when modeling aircraft in the inventories and Steven J. Moskalik and Daniel Wajerski provided data to update the aircraft performance database used in the inventory calculations. The TED/FSCM code used to process flight schedule data was written by David F. Tankersley and the GAEC code used to calculate the aircraft emission inventories was written by Peter S. Hertel. The analysis of the results was completed by Steven L. Baughcum, Donald J. Sutkus and Douglas P. DuBois.

2. Database Development Methodology

The calculation of emission inventories has been described previously (Baughcum, *et al.*, 1994; Baughcum, *et al.*, 1996) and will be briefly summarized here. The overall process is shown schematically in Figure 2-1.

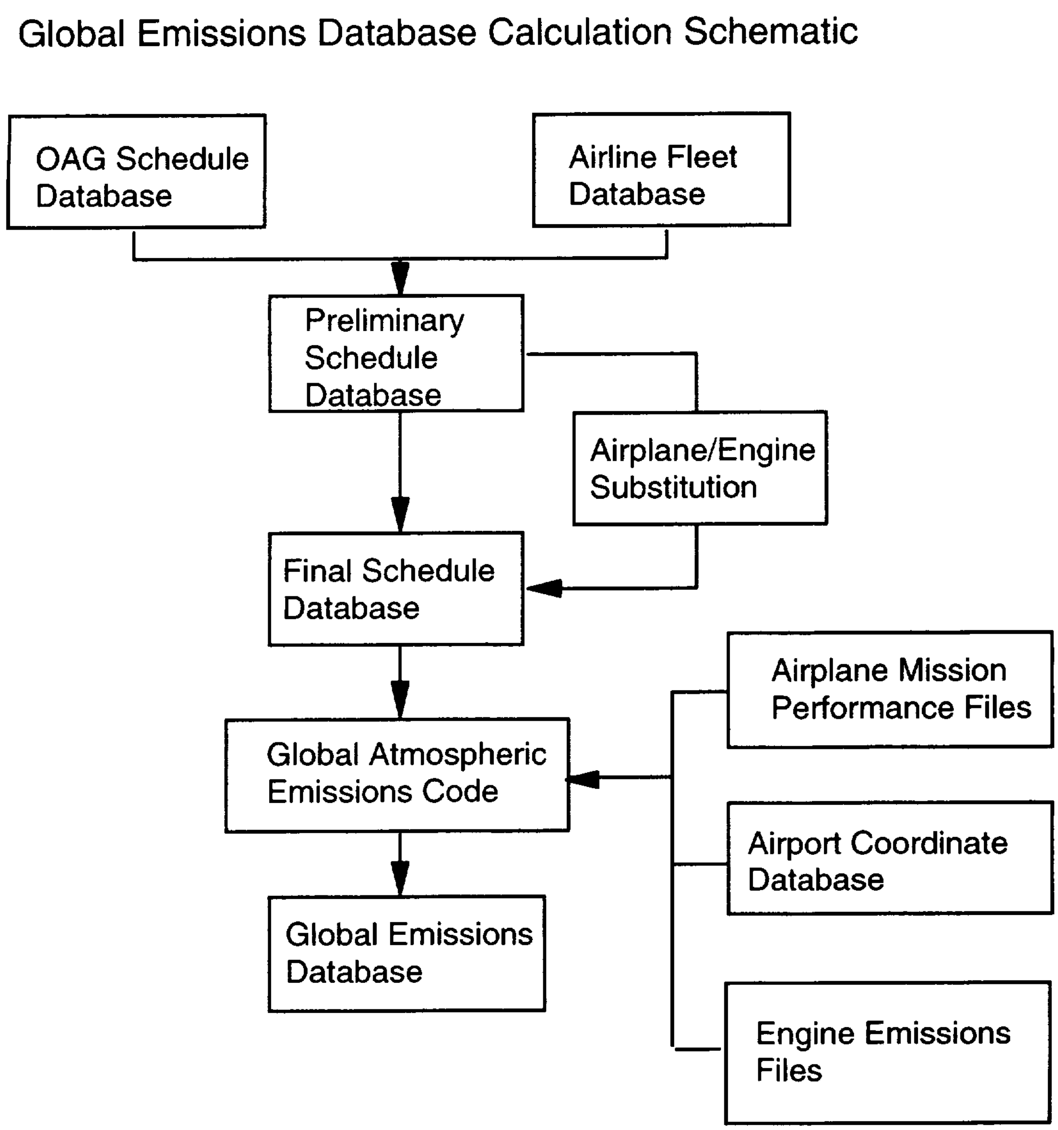


Figure 2-1. Schematic of emission inventory calculation.

2.1 Database Acquisition and Description

The projected flight schedule data used to create the twelve month 1999 global emission inventory for the scheduled aircraft fleet were purchased by The Boeing Company from Official Airline Guide (OAG) (Oakbrook, IL) for four months (January, April, July and October). OAG data purchased in January include schedule forecasts for February, March, and April. The OAG schedule data contain listings of every scheduled jet and turboprop flight by city-pair and airline, and include departure and arrival times, airplane code, and trip frequency projected for several months into the future. This data are processed to create standard flight schedule databases that are used in a variety of airline and airplane studies within The Boeing Company. OAG flights for the 16th through the 22nd of each month were used to represent the entire month in this study. Fuel burned and emissions calculated in this study for this seven day period were divided by seven and multiplied by the number of days in the month to obtain monthly totals.

The coverage of the OAG database depends on schedule data submitted by individual airlines. While it is quite accurate overall, changes in airline planned operations during any month or operations not reported by the airline as part of their schedule are not included. The 1999 OAG did not include charter flights, military flights, general aviation flights and full coverage of freighter flights. In addition, Boeing analysis shows that the 1999 OAG under predicted scheduled air traffic by approximately 25 percent for China and approximately 30 percent for the former Soviet Union (on an available seat kilometer basis). The majority of the under prediction in China and the Soviet Union is for smaller jet aircraft.

The emission inventory calculations reported previously for the 1992 scheduled fleet (Baughcum, *et al.*, 1996a) used published schedule data obtained monthly directly from OAG. For the 1999 scheduled fleet inventory calculations, however, the OAG database normally used by Boeing, which is updated quarterly, was utilized. This means that projections of flight schedule data up to three months into the future were utilized in creating the 1999 scheduled fleet inventory.

In order to evaluate the effect of using schedule data projected for multiple months into the future, scheduled emission inventories for May 1999 were created using both one-month and four-month (from the previous quarter's OAG) projections. The 4-month projection was a longer-range forecast than was actually used in developing the 1999 monthly inventories.

Table 2-1 compares the fuel burned, flight distance, and emissions for selected geographical regions for the one month and four month projections. Globally, fuel burned was under predicted by about 1% and distance by 1.7% by the 4-month projection. NOx, CO, and hydrocarbon emissions were also under predicted globally by the four month projection by approximately 1%. Discrepancies between results of the two projection methods are slightly greater in the Southern Hemisphere than those in the Northern Hemisphere. In the Southern Hemisphere, air traffic appears to have been over predicted by the 4-month projection while air traffic in the Northern Hemisphere was under predicted slightly by the four month projection.

The agreement between the one month and four month projections is within 1-3% for the US, North America, North Atlantic, and North Pacific for fuel burned, distance and emissions, with traffic (flight distance) increasing faster than projected by the 4-month projection. Air traffic in Europe also grew faster than expected from the 4-month projection but the under-prediction was slightly larger (4.5%) than the regions mentioned above. The most dramatic discrepancy is for China where the 4-month projection under-predicted the fuel use by 6% and the flight distance by 10%. The effect on global emissions of this discrepancy is relatively minor though considering that China is responsible for only 4% on global fuel burned (see Table 3-2).

When the one-month and 4-month projections are compared on an airplane by airplane basis, some differences are clearly evident. In general, these manifest themselves as under prediction of fuel use by airplanes which were currently in production (e.g., Boeing 737, Boeing 777, Boeing 757, Airbus A310, Airbus A319, and McDonnell Douglas MD-90), and over prediction of older aircraft (e.g., McDonnell Douglas DC-10, McDonnell Douglas DC-8, Lockheed L-1011). These effects are probably due to retirements, changes in utilization, and introduction of new airplanes.

Overall, from the perspective of using the aircraft emission inventories in global atmospheric modeling assessments, the errors associated with using projections based on quarterly data seem small and acceptable.

An airport listing is needed to calculate global emissions and fuel burn for the scheduled fleet using the OAG schedule. For each three-letter airport code listed in the OAG schedule, the airport listing gives the city name and position (latitude, longitude, and altitude) of the airport. Three-letter airport codes that have been ‘retired’ either because the airport they used to represent no longer exists or because a different code has been assigned to that airport may be re-used by the OAG. For this reason, an airport listing corresponding to the specific month and year for which the inventory calculation is being done must be used when making inventory calculations.

Table 2-1. Regional changes in May 1999 global scheduled fleet emission inventory calculation results due to use of a 4-month projection of OAG flight schedule data instead of a one month projection (positive percent difference denotes an over-prediction by the 4-month projection).

	Global	Northern Hemisphere	Southern Hemisphere
Fuel burned	-0.9%	-1.2%	2.8%
NOx	-1.0%	-1.4%	3.1%
CO	-1.1%	-1.5%	3.5%
Hydrocarbons	-0.6%	-1.1%	4.4%
Distance	-1.7%	-2.0%	1.8%

	US	Europe	North America	North Atlantic	North Pacific	China	Far East
Fuel burned	-1.1%	-2.8%	-1.2%	0.3%	-1.5%	-6.3%	-1.1%
NOx	-1.9%	-2.2%	-1.8%	0.3%	-1.5%	-5.2%	-1.7%
CO	-0.4%	-2.6%	-0.5%	-0.3%	-1.1%	-8.5%	0.5%
Hydrocarbons	-0.2%	-3.3%	-0.4%	-2.8%	-0.4%	-2.6%	6.1%
Distance	-0.9%	-4.5%	-1.0%	1.1%	-1.8%	-10.0%	-2.6%

2.2 Data Extract Challenges

The OAG database is designed for the purpose of travel itinerary planning by airline passengers and travel agents. As a result, certain duplicate listings of the same actual flight segment may occur in the schedule data and legs of trips using transportation modes other than air travel may also be listed. While non-aircraft trip legs are tagged in the database and easily filtered, duplicate listings are not noted explicitly in the database. Logic must be built into an extract code to eliminate these duplications as much as possible.

The logic used to eliminate duplicate flight listings in this study differed from that used in past NASA scheduled inventory studies (Baughcum *et al.*, 1996a and 1996b). The new approach is much more automated, requires less expert judgment by the analyst, and is very reproducible. In order to determine the effect of these differences, a schedule for August 1992 was extracted using the new duplicate removal scheme and compared to the August 1992 schedule used to generate the previously published NASA 1992 scheduled inventory. Differences between the two schedules were minimal and judged to be insignificant.

The flight duplications which must be eliminated fall into three main categories, which we term "Codeshare Duplication", "Starburst Duplication" and "Effectivity Duplication". A description of each of these three categories is given below.

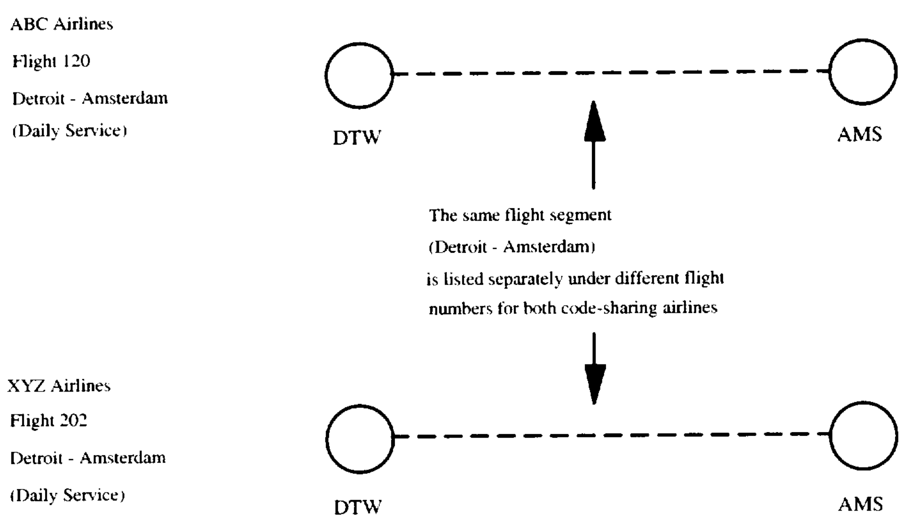


Figure 2-2. "Codeshare" flight duplication.

"Codeshare Duplication"

This form of schedule duplication occurs when both airlines involved in a cooperative flight sharing arrangement (codesharing) will list the same flight segment under their own airline code and flight number. This results in the flight being listed twice in the OAG schedule, once under each airline's name. For instance, the same flight from Detroit to Amsterdam may be listed under both ABC Airlines and XYZ Airlines. Codeshare duplications are removed by checking for flights that are listed under two different airlines, but with the same airport-pair, time of day departure and arrival, same day and same equipment (See Figure 2-2).

A provision to retain certain known "head to head" competition flights was made in the codeshare duplication removal logic. "Head to head" flights are those flights where two airlines have directly competing flights between the same airport-pair with the same departure and arrival times on the same day with the same equipment.

"Starburst Duplication"

This form of duplication arises from the practice of airlines listing under separate flight numbers one-stop or multi-stop itineraries that contain the same flight segment. As a simple example of this practice, an airline listing a one-stop flight from Cleveland to London through New York and another one-stop flight from Washington to London through New York will combine the passengers from both flight numbers on the same New York - London flight segment. The published schedule, however, would lead one to believe that there are two separate flights from New York to London. This duplication is removed by checking flight itineraries for segments listed under the same airline, airport-pair, time of day departure and arrival, same day and equipment. (See Figure 2-3)

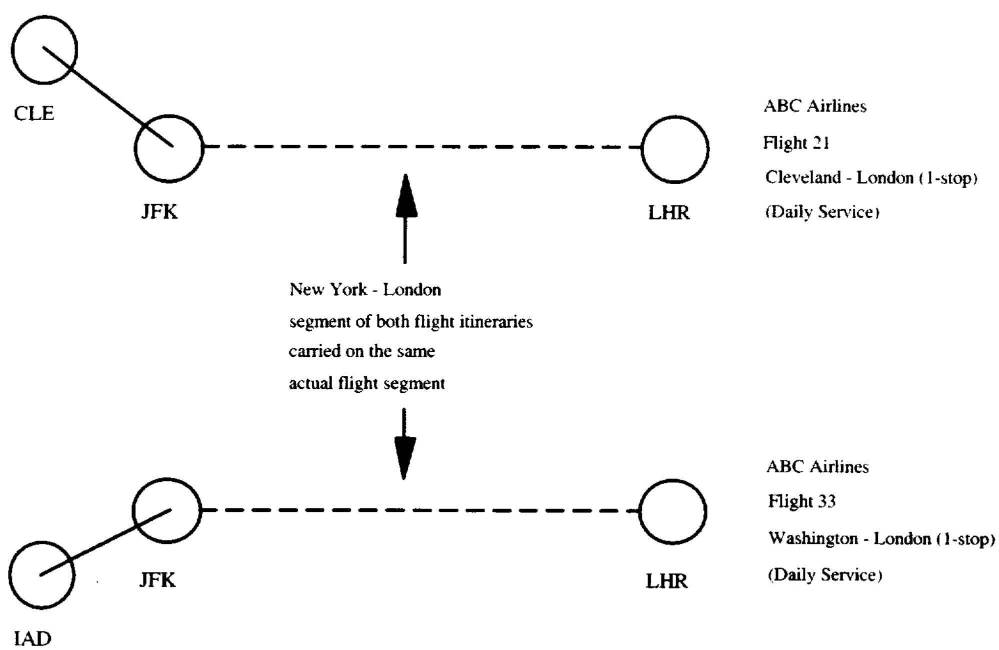


Figure 2-3. "Starburst" flight duplication.

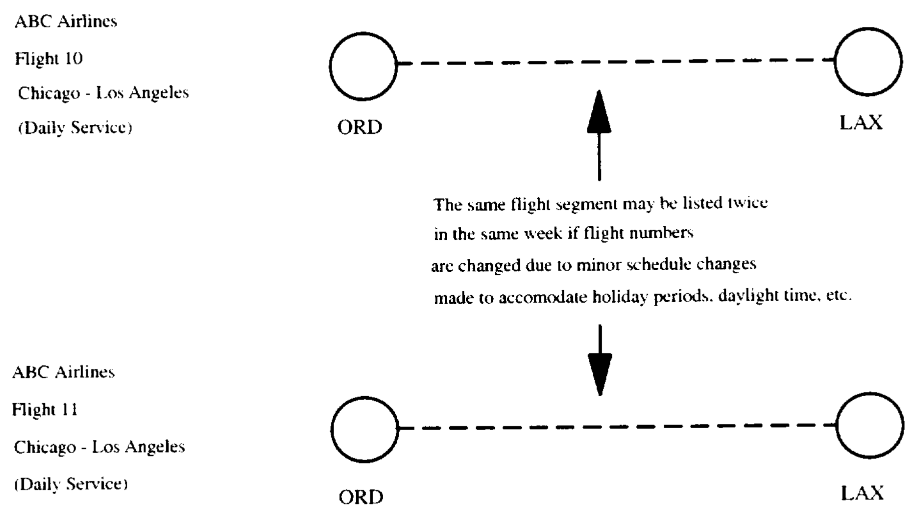


Figure 2-4. "Effectivity" flight duplication.

"Effectivity Duplication"

Although the OAG schedule data are supplied as representing the airline schedules for a certain month, data within the schedules show the dates at which flights cease operation or begin operation within the month. The flight data show which days of the week the flight operates. If every flight that operates in a given week is counted, then the same flight segment may be counted twice as airlines change schedules (and flight numbers) within the week to account for holidays, daylight time, change of airplane type, etc. This duplication can be removed by choosing a single date for flight effectivity, rather than a whole week. All flights effective on the 16th day of the month are included in the analyses presented here. (See Figure 2-4)

Once the logic to remove the types of duplicate flights noted above was in place and tested, a complete set of schedules was extracted for each month of 1999 and August of 1992.

2.3 Creation of the Emissions Database:

2.3.1. Schedule Data Translation

Each flight listing in the monthly airline schedules extracted from the OAG database gives the airline, the airplane type, the origin airport, the destination airport and the number of times the flight is scheduled to fly between the specified airport pair in a one week period. The following is an example of a typical OAG flight database listing:

Airline	Airplane	Origin	Destination	Weekly Freq.
JL	74F	ANC	ATL	3

In order to calculate performance and emissions for a particular flight, the specific type of engine installed on the aircraft must be known. The OAG database flight listings do not contain information about engines installed on an aircraft used for a particular flight. In order to assign engines to flights listed in the OAG database, a fleet information database purchased from the Airclaims Company was used. This database provides a comprehensive listing of the aircraft owned by each of the world's airlines and the engines installed on them. This database differs from the Boeing internal fleet information database that was used to produce previous NASA emission inventories. The database used previously is now out of date and is no longer maintained by Boeing.

A Boeing proprietary computer code was used to automate the process of assigning engines to flights listed in the OAG database using airline fleet information contained in the Airclaims database. Engines were assigned to flights listed in the OAG database using a "majority rules" criteria where the most prevalent engine used in the given airline's fleet on the given airplane type was assigned to the flight.

To illustrate how the Airclaims Database was used to assign engines to flights listed in the OAG schedule database, we will build an example using the sample OAG database flight listed above.

OAG airplane and airline codes are different than Airclaims airplane and airline codes and so airplane and airline code translation tables were necessary to link the two databases. For illustration purposes, simplified airplane and airline translation tables relevant to the current example are shown in Tables 2-2 and 2-3.

Table 2-2. Sample OAG to Airclaims airline code translation table.

OAG Airline Code	Airclaims Airline Code
JL	JAL

Table 2-3. Sample OAG to Airclaims airplane translation table.

OAG Specific Aircraft Code	Airclaims Aircraft Type	Airclaims Aircraft Variant	Airclaims Aircraft Usage
74F	747	200F (SCD) (P&W)	All Freight-Cargo
74F	747	200F (P&W)	All Freight-Cargo
74F	747	200SF (P&W)	All Freight-Cargo

For the current example, using an airline code translation table (like that in Table 2-2), the OAG airline code "JL" would be translated to the Airclaims airline code "JAL". Using the airplane code translation table (like that in Table 2-3), the OAG airplane code "74F" would be translated to the following three possible Airclaims aircraft type/aircraft variant/aircraft usage names: "747/200F (SCD) (P&W)/All Freight-Cargo", "747/200F (P&W)/All Freight-Cargo" and "747/200SF (P&W)/All Freight-Cargo".

Appendix A contains a sample listing from the Airclaims database for the Japan Airlines fleet as it existed on May 16th 1999. Using the "translated" Airclaims airline code and aircraft type/aircraft variant/aircraft usage names along with this Airclaims database sample listing, we find that the 747-200F (SCD) (P&W)/JT9D-7Q aircraft/engine combination is the one that has the largest representation in the Japan Airlines fleet of all combinations corresponding to the OAG schedule's 74F code. Therefore, by use of the "majority rules" criterion, the 747-200F (SCD) (P&W)/JT9D-7Q aircraft/engine combination would be assigned to the sample OAG flight. The "(SCD)" and "(P&W)" would then be stripped from the Airclaims aircraft variant name because they contain no useful information for the inventory calculation process.

With the above process being completed, the OAG listed flight with the new engine assigned using the Airclaims database would be as follows:

Airline	Airplane	Engine	Origin	Destination	Weekly Freq.
JL	747-200F	JT9D-7Q	ANC	ATL	3

Once aircraft performance data and engine emissions data are assigned to the above flight, the emissions for the flight can be calculated.

The make-up of the world's airline fleet is always changing. For this study, a "snapshot" of the Airclaims database as it existed on the 16th of each month was used when performing the schedule data translation. The 16th of the month was chosen in order to coincide with the effectivity date of the OAG schedule data.

2.3.2. Airplane/Engine Performance Data Substitution

In some cases, it was necessary to substitute one type of aircraft/engine combination for another in the translated schedule created using the process described in Section 2.3.1 above. While Boeing has performance information needed to calculate fuel burned for a large number of turbojet-powered airplane types, including all Boeing models and many non-Boeing models, we do not have such information for all airplane types in airline service. For some of these airplane types, performance data for a similar airplane were used to approximate fuel burned. The airplane type in the following flight is an example:

Airline	Airplane	Engine	Origin	Destination	Weekly Freq.
IT	Mercure	JT8D-9	PAR	LYS	21

Boeing does not have enough detailed information on the Dassault Mercure to calculate fuel burned or emissions on this flight. The Mercure is a twin-engined aircraft of similar size to the 737-200, and is powered by the same engines as some of the 737-200 models. The data for this flight can therefore be revised to:

Airline	Airplane	Engine	Origin	Destination	Weekly Freq.
IT	737-200	JT8D-9	PAR	LYS	21

For the RJ-85, RJ-100 and Fokker 70 aircraft types, no aircraft were present in the Boeing performance database that had performance characteristics similar enough to make a reasonable direct substitution. For these aircraft types, the performance characteristics of larger aircraft of the same general type were scaled to provide a reasonable performance estimate.

For emission calculation purposes, all of the myriad turboprop models that existed in the 1999 OAG database were grouped into three categories, small, medium and large. The "small" category includes airplanes such as the DeHaviland Twin Otter, the "medium" category includes airplanes such as the DeHaviland Dash-8, and the "large" category includes airplanes such as the Fokker F-27 and F-50. In addition, performance of all of the various types of regional jets was modeled using a single general regional jet performance model.

Appendix B contains a listing of all the airplane types appearing in the processed 1999 OAG data and the performance airplanes used to model each type in the emissions calculations. For 1999, the number of different airplane/engine combinations listed in the flight schedule data files varied between months from 369 to 387. These airplane/engine combinations were modeled using 89 airplane/engine combinations for which detailed performance and emissions data were available. A list of the 89 performance airplanes used to model the 1999 fleet is shown in Table 2-4.

The number of different airplane/engine combinations listed in the 1999 flight schedule data is considerably higher than the 228-235 different airplane/engine combinations appearing in the flight schedule data for the 1992 NASA inventory. This is partly due to the introduction of new airplane types into the fleet since 1992 and partly because the new process used to create the flight schedule data for the 1999 inventory extracts airplane types at a more detailed level.

Table 2-4. List of airplane-engine combinations used in airplane performance calculations for the 1999 emission inventory.

Airplane	Engine	Airplane	Engine	Airplane	Engine	Airplane	Engine
707-320B-C	JT3D-3B	747-300	RB211-524D4UP	777-300	TRENT892	DC-8-63-63CF	JT3D-7
727-100	JT8D-7	747-300F	CF6-50E2	A300-600R	CF6-80C2	DC-8-71-71CF	CFM56-1B
727-100	JT8D-9	747-400	CF6-80C2-B1F	A300-621R-ER	JT9D-7R4H1	DC10-10	CF6-6D
727-200	JT8D-15-15A	747-400	PW4056	A300-622R-ER	PW4056	DC10-10F	CF6-6D
727-200	JT8D-9	747-400	RB211-524G	A300-B2-B4	CF6-50C2	DC10-40	JT9D-20
727-200F	JT8D-15-15A	747-400F	CF6-80C2B1F	A310-300	CF6-80A3	DC8-55-55CF	JT3D-3B
737-100	JT8D-9	747-400F	PW4056	A310-300	CF6-80C2A2	DC9-30	JT8D-7
737-200	JT8D-15	747-400F	RB211-524H	A310-300	JT9D-7R4E1	DC9-31	JT8D-15
737-200	JT8D-7	747SP	JT9D-7A	A319	CFM56-5B3P-25	DC9-50	JT8D-15
737-200ADV	JT8D-9-9A	747SP	RB211-524C2	A319-200	CFM56-5-A1	F-28-4000	MK555-15H
737-300	CFM56-3-B1	757-200	PW2037	A319-200	V2522-A5	FOKKER-100	TAY-650
737-500	CFM56-3-B1-18.5	757-200	PW2040	A320-200	CFM56-5-A1	FOKKER-70	MARK-620-15
737-600	CFM56-7B18	757-200	RB211-535C	A320-200	CFM56-5B3P-26.5	L-1011-1-100	RB211-22B
737-700	CFM56-7B20	757-200	RB211-535E4	A320-200	V2525-A5	L-1011-1-100F	RB211-22B
737-800	CFM56-7B24	767-200	CF6-80A	A321-100	CFM56-5B1	L1011-500AC	RB211-524B4
737-800	CFM56-7B27	767-200	JT9D-7R4D	A321-100	V2530-A5	MD-11	CF6-80C2D1F
747-100-100SR	CF6-45A2	767-200ER	CF6-80C2B4F	A321-200	V2533-A5	MD-11ER	PW4460
747-100-200	CF6-50E2	767-200ER	PW4056	A330-200	CF6-80E1A3	MD-11F	CF6-80C2D1F
747-100-200	JT9D-7A	767-300	CF6-80A2	A330-200	PW4168	MD-11F	PW4460
747-100F	JT9D-7F	767-300	JT9D-7R4E	A330-200	TRENT772	MD-82	JT8D-217A
747-200	JT9D-7J	767-300ER	CF6-80C2B6F	A330-300	CF6-80E1A1	MD-83	JT8D-219
747-200	JT9D-7R4G2	767-300ER	PW4060	A330-300	PW4164	MD-87	JT8D-217C
747-200	RB211-524C	767-300ER	RB211-524H	A330-300	TRENT768	MD-95-30	BR715
747-200	RB211-524D4U	777-200	PW4084	A340-200	CFM56-5C-2	MD90-30	V2525-D5
747-200B-C-F	JT9D-7Q	777-200	TRENT877	BAC111-500	MK512-14	RJ-100	LF507
747-200F	JT9D-7J	777-200ER	GE90-85B	BAE146-200	ALF502R-5	RJ-85	LF507
747-200F	RB211-524D4	777-200ER	GE90-90B	BAE146-300	ALF502R-5	Small Turboprop	PT6A
747-300	CF6-50E2	777-200ER	PW4084	CRJ (Estimated)	CF34-3A1	Medium Turboprop	PW120
747-300	CF6-80C2B1	777-200ER	TRENT877	DC-10-30	CF6-50C2	Large Turboprop	PW125
747-300	JT9D-7R4G2	777-300	PW4090	DC-10-30F	CF6-50C2	Concorde	Olympus 593

2.3.3. Airplane Mission Performance Calculation

Boeing proprietary performance data files for the airplane/engine combinations shown in Table 2-4 and were used to model all of the airplane/engine combinations listed in the OAG schedule. These data files provide tables of time, fuel burned and distance flown as a function of airplane gross weight and altitude for climbout, climb, and descent conditions. They also provide tables of fuel mileage (nautical miles per pound of fuel burned) as a function of gross weight, cruise Mach number and altitude for cruise conditions and tables of long range cruise Mach number vs. gross weight and altitude. Constant fuel burn rates for taxi-in, taxi-out and approach based on typical mission allowances are also included in these data files. These performance data files were generated using the proprietary Boeing Mission Analysis Program (BMAP), and each file covered the whole operating envelope of the airplane. Simple interpolation routines were used to obtain engine fuel flow for a given flight condition.

Airplane performance calculations were done assuming 70% passenger load factors for all passenger and 'combi' airplanes (airplanes that can be used to carry either passengers or cargo).

Typical payloads for freighter airplanes were determined using cargo loading data reported on the United States Department of Transportation (DOT) Form T-100. DOT Form T-100 data for U.S. domestic flights and flights to and from the U.S. were combined and used to determine the average payload carried by each general freighter airplane type existing in the 1999 OAG flight schedule. For each general freighter type, the average payload carried was added to a typical operating empty weight (OEW) for that airplane type to obtain an 'average' zero fuel weight (ZFW). If the 'average' ZFW for a given general freighter type matched the passenger version's ZFW reasonably well, then performance data for the passenger version loaded at 70% passenger load were used to model it. If the 'average' ZFW for a given general freighter type did not match well with the passenger version's ZFW, then a special performance file for that freighter type was created. This performance file used passenger version operating empty weights (OEW) and an estimated average freighter payload.

Of the 16 general freighter airplane types that existed in the 1999 OAG flight schedule, only the very large freighters (747, Antonov An-124, DC-10, L-1011 and MD-11) had 'average' ZFWs that differed enough from the passenger version ZFW to warrant their being modeled with typical freighter payloads. All other freighter types were modeled as passenger airplanes with 70% passenger load.

Table 2-5 shows the increase in ZFW relative to the 70% passenger loading ZFW for the specific very large freighter airplane types that were modeled using estimated typical freighter payloads.

Table 2-5. Increase in ZFW relative to the 70% passenger loading case for very large freighters.

Specific Freighter Airplane	Freighter Loading ZFW Percent Increase Over PAX Loading ZFW
747-100F_FRT_JT9D-7A	12.5%
747-200C_F_FRT_CF6-50E2	11.4%
747-200F_FRT_CF6-50E2	11.4%
747-200F_FRT_JT9D-7F	19.4%
747-200F_FRT_JT9D-7J	19.4%
747-200F_FRT_JT9D-7Q	19.4%
747-200F_FRT_JT9D-7R4G2	19.4%
747-200F_FRT_RB211-524D4	14.6%
747-200SF_FRT_CF6-50E2	11.4%
747-200SF_FRT_JT9D-7J	19.4%
747-200SF_FRT_JT9D-7Q	19.4%
747-200SF_FRT_JT9D-7R4G2	19.4%
747-200SF_FRT_RB211-524D4	14.6%
747-400F_FRT_CF6-80C2B1F	10.9%
747-400F_FRT_PW4000-4056	15.6%
747-400F_FRT_RB211-524H2	10.2%
An-124-*_FRT_D-18-T	10.9%
DC-10-10F_FRT_CF6-6D	5.7%
DC-10-30F_FRT_CF6-50C2	17.8%
DC-10-30F_FRT_CF6-50C2B	17.8%
L-1011-200_FRT_RB211-524B	11.5%
L-1011-200_FRT_RB211-524B4	11.5%
MD-11-Freighter_FRT_CF6-80C2D1F	16.3%
MD-11-Freighter_FRT_PW4000-4460	13.5%

2.3.4. Calculation of Global Emissions

The primary emissions produced by the combustion of jet fuel are water vapor (H_2O) and carbon dioxide (CO_2). The emission levels of H_2O and CO_2 are determined by the fuel consumption and the fraction of hydrogen and carbon contained in the fuel. Results from a Boeing study of jet fuel properties measured from samples taken from airports around the world have yielded an average hydrogen content of 13.8% (Hadaller and Momenthy, 1989). Emissions of sulfur dioxide (SO_2) from aircraft engines are determined by the levels of sulfur compounds in the jet fuel. Although jet fuel specifications require sulfur levels below 0.3%, they are typically much lower than this in the fuel supply utilized by the world's aircraft fleet. The Boeing measurements obtained an average sulfur content of 0.042% with 90% of the samples below 0.1% (Hadaller and Momenthy, 1989). These measurements are in the range of values reported in more recent fuel surveys (Hadaller, *et al.*, 2000). Future sulfur levels are projected to drop to about 0.02% (Hadaller and Momenthy, 1993).

Aircraft engine emissions are characterized in terms of an emission index, which has units of grams of emission per kilogram of fuel burned. Current and projected emission indices are summarized in Table 2-6, based on the analyses of Hadaller and Momenthy for commercial Jet A fuel.

Table 2-6. Recommended emission indices (in units of grams emission/kilogram fuel).

Emission	Emission Index
Carbon Dioxide (CO_2)	3155
Water (H_2O)	1237
Sulfur oxides (as SO_2)	0.8

Emissions of nitrogen oxides (NO_x), carbon monoxide (CO) and hydrocarbons from an aircraft engine vary in quantity according to the combustor conditions. Nitrogen oxides are produced in the high temperature regions of the combustor primarily through the oxidation of atmospheric nitrogen. Thus, the NO_x produced by an aircraft engine is sensitive to combustor pressure, temperature, flow rate, and geometry. The NO_x emission index varies with the power setting of the engine, being highest at high thrust conditions. By contrast, carbon monoxide and hydrocarbon emission indices are highest at low power settings where combustor temperatures and pressures are low and combustion is less efficient.

Nitrogen oxides consist of both nitric oxide (NO) and nitrogen dioxide (NO_2). For NO_x, the emission index [$EI(NO_x)$] is given as gram equivalent NO_2 to avoid ambiguity. Although hydrocarbon measurements of aircraft emissions by species have been made (Spicer *et al.*, 1992), only total hydrocarbon emissions are considered in this work.

For the majority of the engines considered in this study, emissions data from engine certification measurements (ICAO, 2000) were used to model emissions characteristics. In these measurements, emissions of nitrogen oxides

(NOx), carbon monoxide (CO) and total hydrocarbons (HC) are measured at standard day sea level conditions at four power settings [7% (idle), 30% (approach), 85% (climbout) and 100% (takeoff)]. If the ICAO database did not contain a particular engine, the data for that engine were obtained from the engine manufacturer. This was done for the three sizes of turboprops considered. If a source could not be found (e.g., JT3C and JT4A), engines with a similar core were used with an adjustment for different fuel flow rates.

In the global emissions calculations, each OAG airplane/engine combination is matched to both a performance engine and an emissions engine (see Appendix B for the matchup table). Fuel flow is calculated using the performance data. Then the emissions are calculated using the fuel flow based technique discussed later in this section.

In most cases, the emissions engine used to model an airplane was the same as that used to calculate the performance. In some cases, performance data for the airplane model identified in the processed OAG flight schedule were available but the engine assumed in the performance data was different than the engine identified in the schedule. In the majority of these cases, the basic engine type is matched but not the specific maximum take-off thrust rating (a 737-700/CFM56-7B20 airplane/engine combination listed in the OAG schedule might be modeled using 737-700/CFM56-7B18 performance data).

If the engine identified in the processed OAG schedule for a particular airplane was similar to the engine assumed in the performance data used to model the airplane, the emissions engine was selected to match the OAG engine. If the engine identified in the processed OAG schedule was significantly different from the engine assumed in the performance data, the emissions engine was selected to match the performance engine.

Boeing has developed an empirical method that allows the calculation of emissions for a wide variety of airplanes and a large number of missions. This method was described in detail previously (Baughcum, *et al.*, 1996a, Appendix D) and is referred to as the Boeing Fuel Flow Method #2. In this method, emission indices measured during sea level static engine certification tests are correlated with engine fuel flow and then scaled for ambient temperature, pressure, flight Mach number and humidity to determine emissions at flight conditions.

All global emissions calculations were done using the GAEC (Global Atmospheric Emissions Code) as described previously (Baughcum, *et al.*, 1994; Baughcum, *et al.*, 1996a). The GAEC graphical user interface was used to associate airplane/engine combinations listed in the OAG airplane schedule with the performance and emissions data that were used to model them in the inventory calculation. Once these associations were made, the GAEC was used to calculate a global emission inventory using OAG schedule data, performance data, emissions data and airport location data.

For purposes of the emissions calculations, the Earth's atmosphere was divided into a grid of three-dimensional cells with dimensions of 1 degree of latitude by 1 degree of longitude by 1 kilometer in altitude, up to 22 kilometers.

2.5 Methodology Changes from Previous Boeing Inventory Calculations

The methodology used to create the 1999 scheduled aircraft fleet global emission inventory documented in this report is slightly different from the methodology used to calculate the NASA full year 1992 scheduled aircraft fleet emission inventory (Baughcum, *et al.,* 1996a). Differences between the two methodologies are as follows:

1. A new procedure was used to extract flight schedules from OAG data for creating the 1999 inventory. The new procedure uses the same basic OAG flight schedule data for input as the previously used procedure and utilizes similar algorithms to filter double counted flights from the data but is much more automated, requires less expert judgment by the analyst, and is more reproducible. The new procedure uses a different fleet information database to assign engines to a specific OAG airplane type. The new procedure utilizes the commercially available "Airclaims" database for fleet information (See Appendix A for a sample of Airclaims fleet information data) instead of the Boeing proprietary fleet information database called "Jet Track" which was utilized by the previously used procedure. The "Jet Track" database is no longer in use by the Boeing company.

2. OAG schedules forecasted up to three months into the future were used for the current work while published schedules for each month of the year were used to create the 1992 scheduled aircraft fleet emission inventory (see Section 2.1).

3. In the current work, some specific airplane/engine types were modeled using different emissions and/or performance data than those used in the 1992 full year scheduled aircraft fleet emission inventory calculations. As noted earlier, the 1999 study uses a larger set of airplane performance and engine data.

4. As discussed in Section 2.3.3 of this report, some freighter airplanes were modeled differently in the current work than in previous NASA scheduled inventory calculations by using a more realistic payload.

To quantify the effects of the above methodology changes, the NASA emission inventory for August 1992 scheduled aircraft was recalculated using the same methodology that was used to create the 1999 scheduled aircraft inventory. Global totals of fuel burned, distance traveled and NOx emissions for the recalculated August 1992 inventory compared well with the global totals for August 1992 reported previously (Baughcum, *et al.*, 1996a). Totals by general aircraft classes (737, A320, etc.) were also compared between the original and recalculated August 1992 inventories.

A comparison of the recalculated August 1992 inventory and the previously published August 1992 inventory shows that global totals for distance are in excellent agreement, differing by only 0.1%. Distance totals for general aircraft classes also compared well between the previous and recalculated inventories, they differed from one another by no more than 1.8%. The agreement in distance totals indicates that the new procedure used to extract flight schedules from OAG data gives results that are very similar to the previously used procedure.

Comparisons between the new and old calculations for global totals of NOx, CO and hydrocarbon emissions and fuel burned show differences of -0.3%, 19.7%, 18.2% and 0.0% respectively (a positive percent difference in these and the comparisons that follow indicates that values for the recalculated inventory are greater than the previously published inventory). Totals of NOx, CO and hydrocarbon emissions for some general aircraft classes differed between the two inventory calculations significantly more than the global totals did.

The differences in NOx, CO and hydrocarbon emissions between the recalculated and the previously calculated August 1992 inventories are due to differences in the emissions characteristics selected to model specific engines in the two inventory calculations.

Some engine types have had more than one combustor type implemented during their production run. For some engines used on a significant number of flights flown by the 1992 scheduled aircraft fleet, NOx, CO and hydrocarbon emission indices can change dramatically depending on the combustor selected for the engine. Further study and more complete data regarding implementation of various combustor options has led to a revised distribution and assignment of combustors for selected engine types. These revised assignments were used for the August 1992 recalculated inventory so they would be consistent with combustor assumptions made when creating the 1999 inventory.

Because of the changes in methodology discussed above, in order to do a self consistent trend analysis of emissions and fuel burn from 1976 to 1999, the previously published 1976 and 1984 inventories would have to be recalculated using the same methodology that was used to create the 1999 scheduled inventory if trends in hydrocarbon or carbon monoxide emissions are required. Recalculation of the 1976 and 1984 emission inventories is beyond the scope of the current work but should be considered for the future. The analysis suggests that trends of fuel burn and NOx emissions would not be impacted by the change in methodology, at least in terms of global totals. A more detailed analysis would be required to evaluate whether this is true for regional and "by-aircraft" trends as well.

3. Results and Analysis - Scheduled Aircraft Emissions

3.1 Overview of Results

The fuel burned and emissions calculated for the scheduled aircraft fleet for each month of 1999 are summarized in Table 3-1.

Table 3-1. Fuel burned and emissions for scheduled air traffic for each month of 1999.

Month	Fuel (kg/day)	NOx (kg/day)	HC (kg/day)	CO (kg/day)	Distance (km/day)
January	3.42E+08	4.49E+06	5.30E+05	1.87E+06	6.80E+07
February	3.40E+08	4.48E+06	5.24E+05	1.86E+06	6.82E+07
March	3.43E+08	4.52E+06	5.20E+05	1.86E+06	6.88E+07
April	3.45E+08	4.54E+06	5.12E+05	1.85E+06	6.90E+07
May	3.47E+08	4.58E+06	5.14E+05	1.87E+06	7.01E+07
June	3.57E+08	4.70E+06	5.24E+05	1.90E+06	7.21E+07
July	3.61E+08	4.75E+06	5.28E+05	1.92E+06	7.27E+07
August	3.64E+08	4.80E+06	5.36E+05	1.94E+06	7.36E+07
September	3.57E+08	4.70E+06	5.23E+05	1.91E+06	7.26E+07
October	3.54E+08	4.66E+06	5.12E+05	1.88E+06	7.21E+07
November	3.46E+08	4.58E+06	4.90E+05	1.82E+06	7.02E+07
December	3.50E+08	4.64E+06	4.93E+05	1.83E+06	7.10E+07
Total	1.28E+11 kg/year	1.69E+09 kg/year	1.89E+08 kg/year	6.85E+08 kg/year	2.58E+10 km/year

The geographical distribution of the NOx emissions calculated for May 1999 scheduled air traffic is shown in Figures 3-1 and 3-2. This distribution is representative of the geographical distributions of fuel burn, NOx, CO and hydrocarbon emissions for scheduled air traffic for all months of 1999.

Figure 3-1 shows cruise emissions (9-13 km altitude band) as a function of latitude and longitude. As in scheduled inventories previously calculated for 1976, 1984 and 1992, peak emissions occur over the United States, Europe, the North Atlantic flight corridor, and Japan.

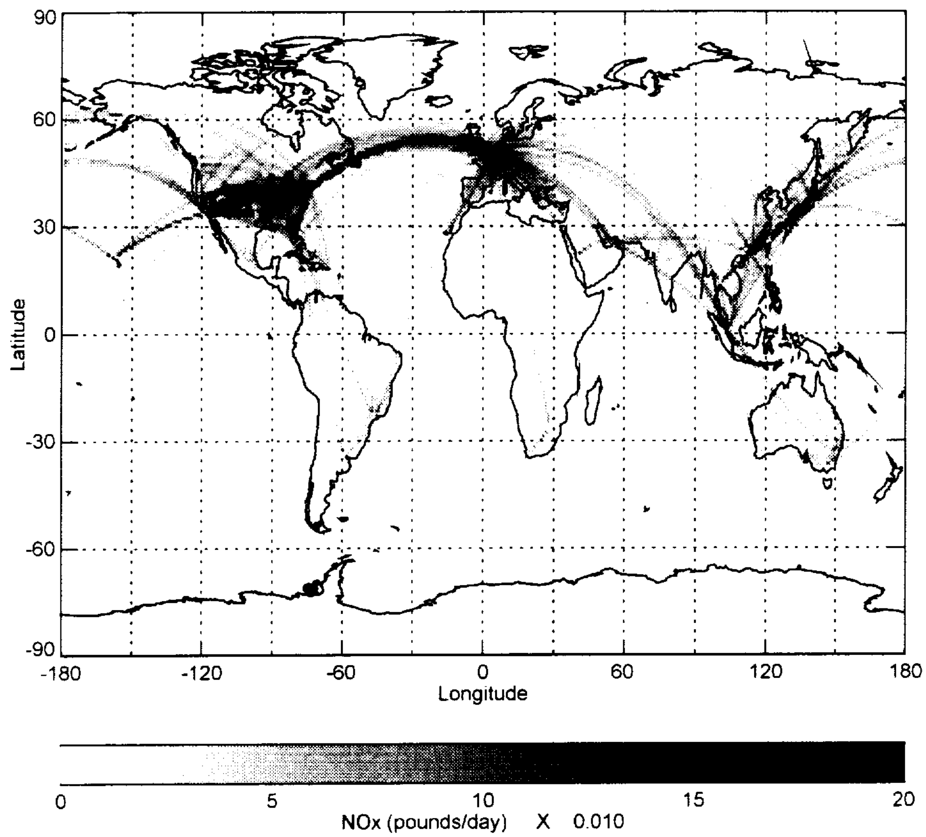


Figure 3-1. Global cruise (9-13 km) NOx distribution for the scheduled aircraft fleet, May 1999.

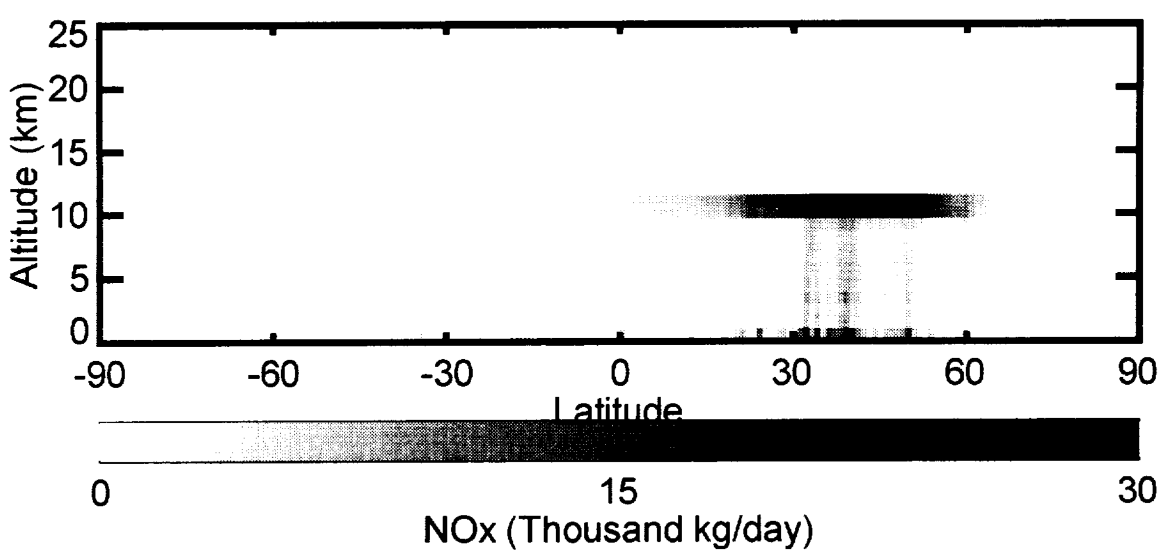


Figure 3-2. NOx emissions for the scheduled aircraft fleet, May 1999, as a function of altitude and latitude (summed over longitude).

Figure 3-2 shows NOx emissions as a function of altitude and latitude. This figure illustrates that the majority of global NOx emissions occur between 30° North and 60° North latitude at typical cruise altitudes (9-13 km).

Approximately 91 percent of emissions from the scheduled aircraft fleet are produced in the Northern Hemisphere. Table 3-2 shows the percentage of global fuel burned, NOx emitted and distance traveled amongst seven selected regions of the world for May 1999. The largest percentage of global fuel burned and emissions occur over the United States and Europe.

Table 3-2. Percentage of global fuel burned, NOx emitted and distance traveled in selected regions of the world by the May 1999 scheduled aircraft fleet.

	US	Europe	North America	North Atlantic	North Pacific	China	Far East
Fuel burned	30%	14%	32%	4%	3%	4%	3%
NOx	28%	14%	30%	4%	3%	5%	4%
Distance	39%	16%	41%	3%	2%	4%	2%

Distributions of fuel burned and emissions as a function of altitude are shown in Figure 3-3. This figure shows that peak fuel burned and NOx emissions occur at cruise altitudes, while peak CO and hydrocarbon emissions occur during the landing/takeoff cycle in the 0-1 km altitude band. Approximately 31% of the fuel burned and 35% of NOx emissions occur below 9 km while approximately 70% of the hydrocarbon and carbon monoxide emissions are emitted below 9 km.

The plots of fuel burned and emissions as a function of latitude in Figure 3-4 emphasize that peak emissions from the scheduled fleet occur at northern mid-latitudes, with the majority of emissions occurring between 30° North and 60° North latitude.

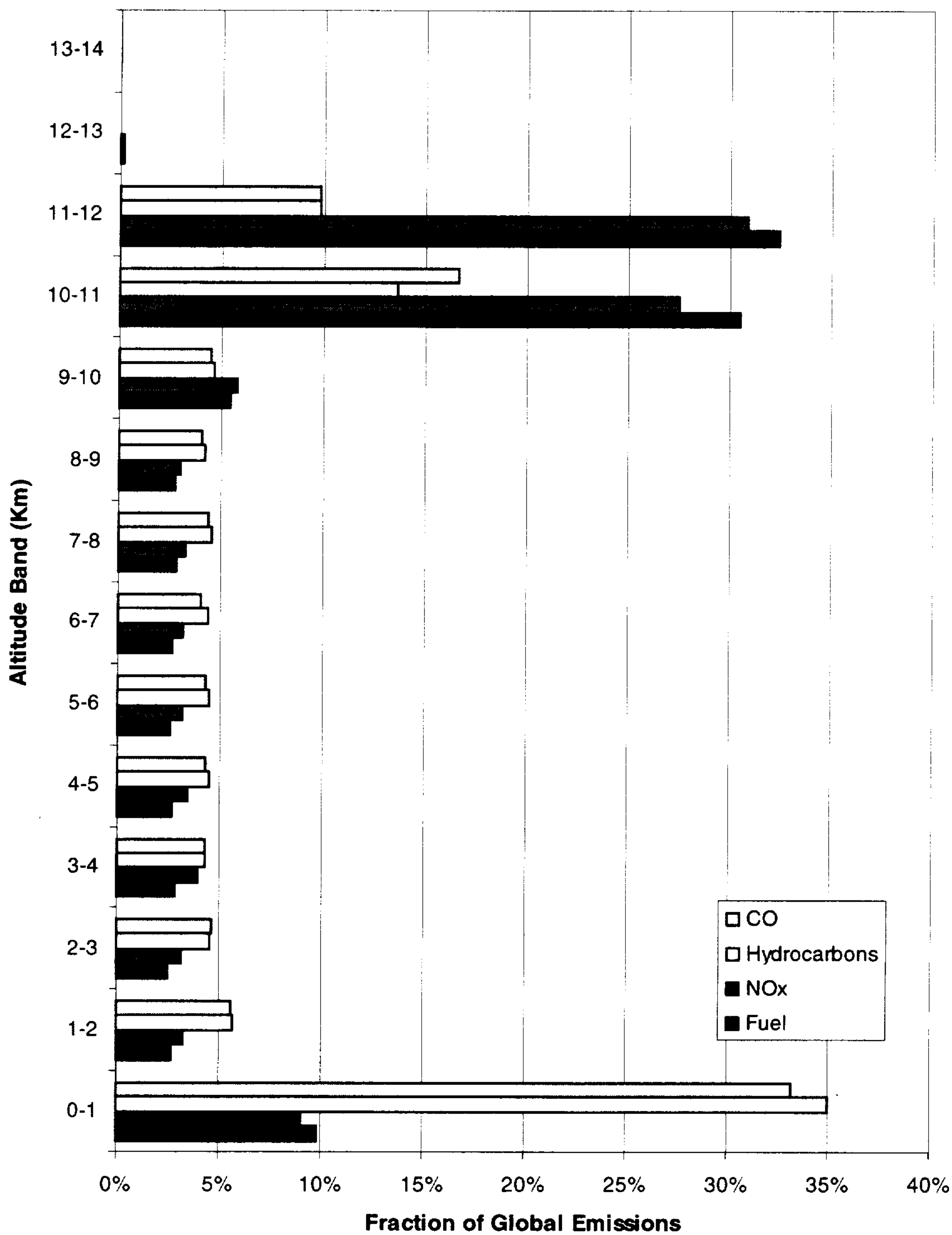


Figure 3-3. Altitude distribution of fractional fuel burned and fractional global emissions of CO, Hydrocarbons and NOx for the scheduled aircraft fleet, May 1999.

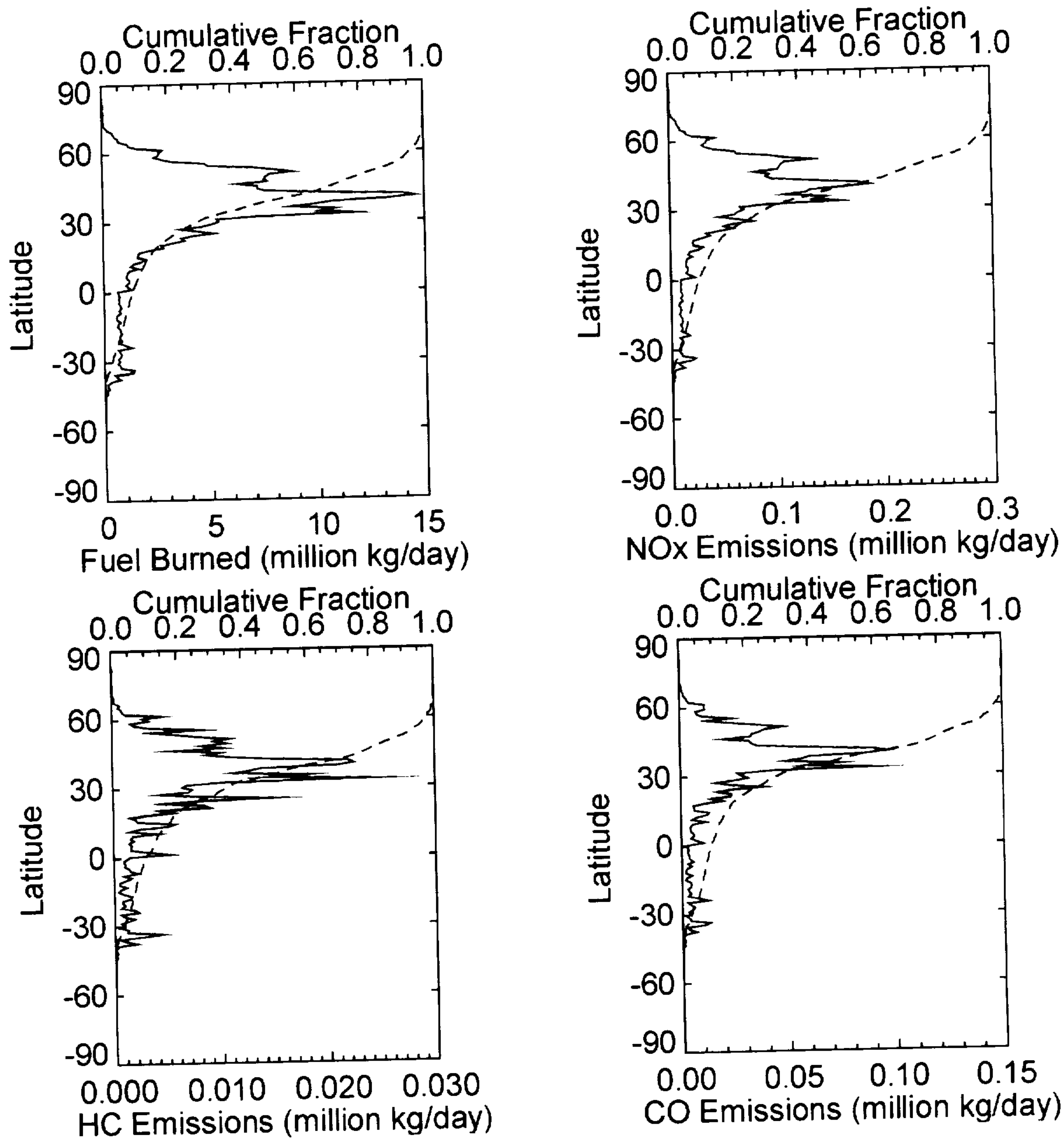


Figure 3-4. Fuel burned and emissions (solid line) as a function of latitude for scheduled May 1999 air traffic. Dashed lines show the cumulative fraction of emissions.

3.2 *Fleet Movement Statistics, Fuel Usage and Effective Emission Indices*

To summarize results of the emission inventory calculations, specific aircraft types were grouped into general aircraft classes and their fuel burned, emissions, departures and distance traveled were totaled. Global effective emission indices for each general aircraft class were also calculated for the 1-9 km and 9-13 km band. Here we define an effective emission index as the ratio of emittant integrated over a given geographical region (latitude, longitude, altitude band) to the integrated fuel use over the same region. Effective emission indices reported herein were calculated using global emissions and are therefore referred to as *global* effective emission indices.

Fleet movement statistics for May 1999 by general aircraft class are summarized in Table 3-3. This table shows the total daily distance flown, the daily departures, and their fraction of the global total for each general aircraft class. It also shows the average route distance for each general class. A more detailed summary identifying similar results for each specific OAG airplane/engine combination in a given aircraft class is provided in Appendix E, which also identifies how each of the general aircraft classes in Table 3-3 is defined. The statistics for May 1999 shown in Table 3-3 and Appendix E are representative of those for all other months in 1999.

Table 3-3. Summary of departure statistics by general aircraft type for May 1999.

General Type	Daily Departures	% of Global Departures	Distance (km/day)	% of Global Distance	Average Route Distance (km)
Turboprops	21,296	30.56%	6,608,584	9.43%	310
Boeing 737-300/400/500	10,224	14.67%	9,147,802	13.05%	895
MD-80	5,397	7.74%	5,619,233	8.02%	1,041
Boeing 737-100/200	4,013	5.76%	3,176,590	4.53%	792
DC-9	3,346	4.80%	2,379,550	3.39%	711
Regional Jets	3,198	4.59%	2,096,416	2.99%	656
Airbus A320	3,071	4.41%	3,818,451	5.45%	1,243
Boeing 757-200	2,741	3.93%	4,828,701	6.89%	1,762
Boeing 727-200	2,353	3.38%	2,532,550	3.61%	1,077
Fokker 100	1,697	2.43%	1,079,091	1.54%	636
Boeing 767-300	1,533	2.20%	4,043,356	5.77%	2,638
Boeing 747-400	1,006	1.44%	5,664,264	8.08%	5,632
BAE 146	993	1.43%	630,398	0.90%	635
Airbus A300-600	825	1.18%	1,012,579	1.44%	1,228
Boeing 737-600/700/800	771	1.11%	1,047,151	1.49%	1,357
Russian Aircraft	701	1.01%	1,266,310	1.81%	1,806
Fokker 28	626	0.90%	358,254	0.51%	572
Boeing 747-100/200/300	570	0.82%	2,573,174	3.67%	4,517
Airbus A319	537	0.77%	692,169	0.99%	1,289
Boeing 767-200	492	0.71%	1,417,564	2.02%	2,884
Boeing 777-200	473	0.68%	1,583,564	2.26%	3,345
Airbus A310	464	0.67%	1,044,357	1.49%	2,251
Airbus A321	448	0.64%	361,687	0.52%	807
MD-90	442	0.63%	331,624	0.47%	750
DC-10	379	0.54%	1,523,344	2.17%	4,022
MD-11	308	0.44%	1,541,979	2.20%	5,006
DC-8	266	0.38%	451,733	0.64%	1,699
Boeing 727-100	261	0.37%	205,915	0.29%	789
Airbus A330-300	250	0.36%	510,219	0.73%	2,044
Airbus A340-300	224	0.32%	1,250,423	1.78%	5,589
Airbus A300-B2/B4/F4	199	0.29%	273,690	0.39%	1,377
Fokker 70	198	0.28%	149,699	0.21%	756
Lockheed L-1011	140	0.20%	288,761	0.41%	2,058
Boeing 777-300	82	0.12%	131,672	0.19%	1,614
BAC111	57	0.08%	45,221	0.06%	797
Boeing 707	41	0.06%	105,766	0.15%	2,607
Airbus A330-200	39	0.06%	138,796	0.20%	3,572
Airbus A340-200	20	0.03%	140,216	0.20%	6,961
Concorde	6	0.01%	33,890	0.05%	5,648
Miscellaneous	5	0.01%	3,013	0.00%	659
Total	**69,690**		**70,107,755**		

Tables 3-4 and 3-5 show a summary of average daily fuel burned, global effective emission indices and the fractional contribution to the global fuel burned and emissions totals calculated for May 1999 for each general aircraft class. In Table 3-4, separate global effective emission indices are shown for NOx, CO and hydrocarbons for the 1-9 km band and the 9-13 km band. A more detailed summary of global effective emission indices showing the results for each OAG airplane/combination is included as Appendix D. Some variation in the global effective emission indices listed in Appendix D may occur between similar aircraft/engine types because of differences in average mission distances flown by them and differences in engine and performance data used to model them.

The data in Table 3-4 represent results of calculations done assuming typical OEWs and average seat counts and load factors, actual configurations and loading will be unique to specific operators and routes.

Table 3-3 shows that global departures are dominated by smaller aircraft (turboprops, 737s, MD-80s, DC-9s and regional jets) with 31% of global departures being made by turboprop aircraft alone. Tables 3-4 and 3-5 show that no general aircraft class dominates global scheduled aircraft fleet fuel burned and NOx emissions. These tables show that roughly 48% of scheduled fleet fuel was consumed and 52% of scheduled fleet NOx was created by large long-range aircraft (747s, A340s, L-1011s, DC-10s, 777s and 767s).

Table 3-4. Summary of fuel burned and global effective emission indices for commercial aircraft types (based on May 1999 scheduled air traffic).

General Type	Fuel (1000 kg/day)	% of Global Scheduled Traffic Fuel Burned	1-9 km Altitude Band			9-13 km Altitude Band		
			EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)
Boeing 747-400	59,837	17.22%	25.3	8.1	1.9	13.3	1.0	0.4
Boeing 737-300/400/500	30,765	8.85%	13.23	11.5	0.9	9.6	3.5	0.2
Boeing 747-100/200/300	30,638	8.82%	27.51	15.4	10.2	15.2	2.2	1.1
MD-80	22,367	6.44%	15.96	4.2	1.2	10.6	4.4	1.6
Boeing 767-300	22,153	6.37%	21.33	7.0	1.4	12.5	1.2	0.3
Boeing 757-200	19,717	5.67%	18.64	8.4	0.5	11.0	1.7	0.1
Boeing 727-200	14,334	4.12%	11.91	9.6	3.1	8.3	5.4	1.0
DC-10	12,679	3.65%	24.23	7.5	2.8	14.9	2.0	0.9
Boeing 737-100/200	12,223	3.52%	11.18	10.0	3.3	7.1	6.8	1.3
MD-11	11,952	3.44%	18.98	5.9	0.5	12.9	1.2	0.1
Airbus A320	11,884	3.42%	17.45	5.6	0.5	12.0	2.0	0.4
Boeing 777-200	11,260	3.24%	25.17	5.4	6.0	16.8	0.6	0.3
DC-9	9,130	2.63%	10.99	11.8	4.2	7.6	6.7	1.0
Turboprops	8,788	2.53%	11.92	3.8	0.2			
Airbus A340-300	8,242	2.37%	22.97	11.3	4.7	13.7	1.7	0.2
Russian Aircraft	7,138	2.05%	12.33	15.5	9.0	9.2	8.4	1.5
Boeing 767-200	7,110	2.05%	22.6	6.6	1.6	11.1	2.0	0.3
Airbus A300-600	6,397	1.84%	17.77	10.1	2.0	12.2	1.7	0.3
Airbus A310	5,298	1.52%	18.46	15.3	4.7	11.3	2.2	0.6
Regional Jets	4,479	1.29%	11.63	9.4	1.4	9.1	0.6	0.1
Fokker 100	3,444	0.99%	11.05	21.0	2.0	6.4	7.0	1.0
Airbus A330-300	3,402	0.98%	23.04	7.0	1.5	14.5	1.3	0.5
Boeing 737-600/700/800	3,219	0.93%	16.32	6.4	0.9	11.8	1.8	0.3
DC-8	2,883	0.83%	11.24	16.3	11.2	8.6	7.2	1.4
Lockheed L-1011	2,415	0.70%	18.74	19.4	13.6	14.4	9.0	2.2
BAE 146	2,330	0.67%	9.14	5.0	0.5	7.8	1.6	0.1
Airbus A319	2,048	0.59%	14.55	5.7	0.7	10.9	2.5	0.3
Airbus A300-B2/B4/F4	2,004	0.58%	22.17	13.1	5.2	14.5	1.9	1.2
Airbus A321	1,405	0.40%	17.45	6.4	0.6	13.3	1.7	0.2
MD-90	1,243	0.36%	16.44	5.2	0.1	11.9	1.8	0.1
Fokker 28	1,211	0.35%	10.47	13.5	7.8	7.4	7.2	2.7
Boeing 777-300	1,131	0.33%	24.77	4.4	10.3	15.7	0.8	0.5
Boeing 727-100	1,094	0.31%	10.8	14.8	5.7	7.1	10.2	2.1
Airbus A340-200	910	0.26%	23.05	11.2	4.6	13.7	1.8	0.1
Airbus A330-200	848	0.24%	24.34	6.5	1.0	16.3	1.6	0.3
Boeing 707	607	0.17%	8.35	31.6	39.4	5.4	17.9	8.5
Fokker 70	453	0.13%	10.3	5.3	1.2	7.1	2.7	1.0
Concorde	351	0.10%	11.03	18.5	1.3	10.0	26.1	1.8
BAC111	158	0.05%	14.44	25.5	15.1	10.1	14.7	6.0
Miscellaneous	5	0.00%	8.61	15.8	2.3	7.3	0.8	0.2

Table 3-5. Fractional contribution of each commercial airplane type to global fuel burned and emissions totals for May 1999 scheduled traffic. (Summed over all altitudes, latitudes, and longitudes)

General Type	Fuel	NOx	HC	CO	Distance
Boeing 747-400	17.22%	18.94%	6.68%	6.67%	8.08%
Boeing 737-300/400/500	8.85%	7.22%	3.91%	14.79%	13.04%
Boeing 747-100/200/300	8.82%	11.17%	15.36%	7.86%	3.67%
MD-80	6.44%	6.04%	6.75%	5.68%	8.01%
Boeing 767-300	6.37%	6.78%	2.73%	3.43%	5.77%
Boeing 757-200	5.67%	5.55%	0.87%	4.46%	6.89%
Boeing 727-200	4.12%	3.04%	6.34%	6.56%	3.61%
DC-10	3.65%	4.45%	4.08%	2.74%	2.17%
Boeing 737-100/200	3.52%	2.36%	6.44%	6.40%	4.53%
MD-11	3.44%	3.53%	0.42%	1.28%	2.20%
Airbus A320	3.42%	3.51%	1.04%	2.58%	5.45%
Boeing 777-200	3.24%	4.42%	4.13%	1.10%	2.26%
DC-9	2.63%	1.72%	6.85%	6.25%	3.39%
Turboprops	2.53%	2.13%	0.53%	2.13%	9.42%
Airbus A340-300	2.37%	2.63%	1.00%	1.33%	1.78%
Boeing 767-200	2.05%	2.01%	0.95%	1.27%	2.02%
Russian Aircraft	2.05%	1.53%	7.52%	4.92%	1.83%
Airbus A300-600	1.84%	1.93%	1.36%	2.07%	1.44%
Airbus A310	1.52%	1.46%	1.65%	1.67%	1.49%
Regional Jets	1.29%	1.01%	0.83%	1.82%	2.99%
Fokker 100	0.99%	0.62%	1.14%	3.04%	1.54%
Airbus A330-300	0.98%	1.24%	0.57%	0.65%	0.73%
Boeing 737-600/700/800	0.93%	0.92%	0.41%	0.77%	1.49%
DC-8	0.83%	0.57%	2.85%	1.82%	0.64%
Lockheed L-1011	0.69%	0.82%	3.51%	1.90%	0.41%
BAE 146	0.67%	0.43%	0.22%	0.67%	0.90%
Airbus A319	0.59%	0.54%	0.23%	0.50%	0.99%
Airbus A300-B2/B4/F4	0.58%	0.74%	1.37%	0.93%	0.39%
Airbus A321	0.40%	0.47%	0.13%	0.44%	0.52%
MD-90	0.36%	0.38%	0.02%	0.32%	0.47%
Fokker 28	0.35%	0.22%	5.18%	1.43%	0.51%
Boeing 777-300	0.33%	0.45%	1.24%	0.15%	0.19%
Boeing 727-100	0.31%	0.21%	0.81%	0.76%	0.29%
Airbus A340-200	0.26%	0.29%	0.09%	0.14%	0.20%
Airbus A330-200	0.24%	0.33%	0.07%	0.12%	0.20%
Boeing 707	0.17%	0.08%	2.13%	0.76%	0.15%
Fokker 70	0.13%	0.09%	0.12%	0.17%	0.21%
Concorde	0.10%	0.12%	0.09%	0.18%	0.05%
BAC111	0.05%	0.04%	0.38%	0.20%	0.06%

There has been some confusion in the scientific literature and with various emission inventory calculations with regard to emission indices at flight altitudes. Most of the available data are from certification measurements at sea level conditions (International Civil Aviation Organization (ICAO), 2000). In some cases, these have been used incorrectly as being representative of the emission levels at cruise conditions, without corrections being used for ambient conditions of pressure and temperature.

In order to help reduce the confusion about the global effective emission indices for commercial aircraft, Table 3-4 shows the global effective emission indices for NOx, CO, and hydrocarbons for each general aircraft class. Global effective emission indices are shown for two altitude bands: 1-9 km (climb and descent averaged together) and 9-13 kilometers (primarily cruise but some final climb and initial descent).

These global effective emission indices represent our best estimate of fleet averages (averaged over all missions) and should not be compared directly with an emission index measured behind an individual aircraft in flight. The methodology used to calculate emissions at altitude in this study (see Section 2.3.4 of this report) can be used for such a comparison if accurate and precise measurements of actual fuel flow, ambient temperature, ambient pressure, humidity, Mach number and corresponding emission index are made. Comparisons with in-flight emission index measurements should provide a way to evaluate the accuracy of the emission methodology used to calculate the inventories documented in this report.

Care must be exercised if attempting to use the information in Table 3-3 and Table 3-4 to calculate fuel efficiencies for the various general aircraft classes. Any aircraft fuel efficiency comparison requires a consideration of the amount of payload (passengers and freight) being carried by each aircraft for a given mission length. Comparisons of aircraft on a strict fuel burn per distance traveled basis without normalizing the data for the number of passengers carried may result in misleading comparisons.

Figure 3-5 illustrates this point. This figure contains plots of fuel burned per kilometer traveled (top panel) and fuel burned per passenger kilometer traveled (bottom panel) as a function of mission length for a 747-400 and an MD-11ER. The top panel of Figure 3-5 shows that the fuel burned per kilometer for the MD-11ER is significantly lower (approximately 46 percent) than that of the 747-400 for all mission lengths shown. This though is a misleading comparison because the number of passengers carried by the MD-11ER is less than that carried by the 747-400. The bottom panel of Figure 3-5 shows the effect of normalizing the data by average seat count. Fuel burned per ASK (available seat kilometer) is plotted versus mission range. For this comparison the fuel burned per ASK values for the 747-400 and MD-11ER are within 6 percent of each other for all mission lengths shown.

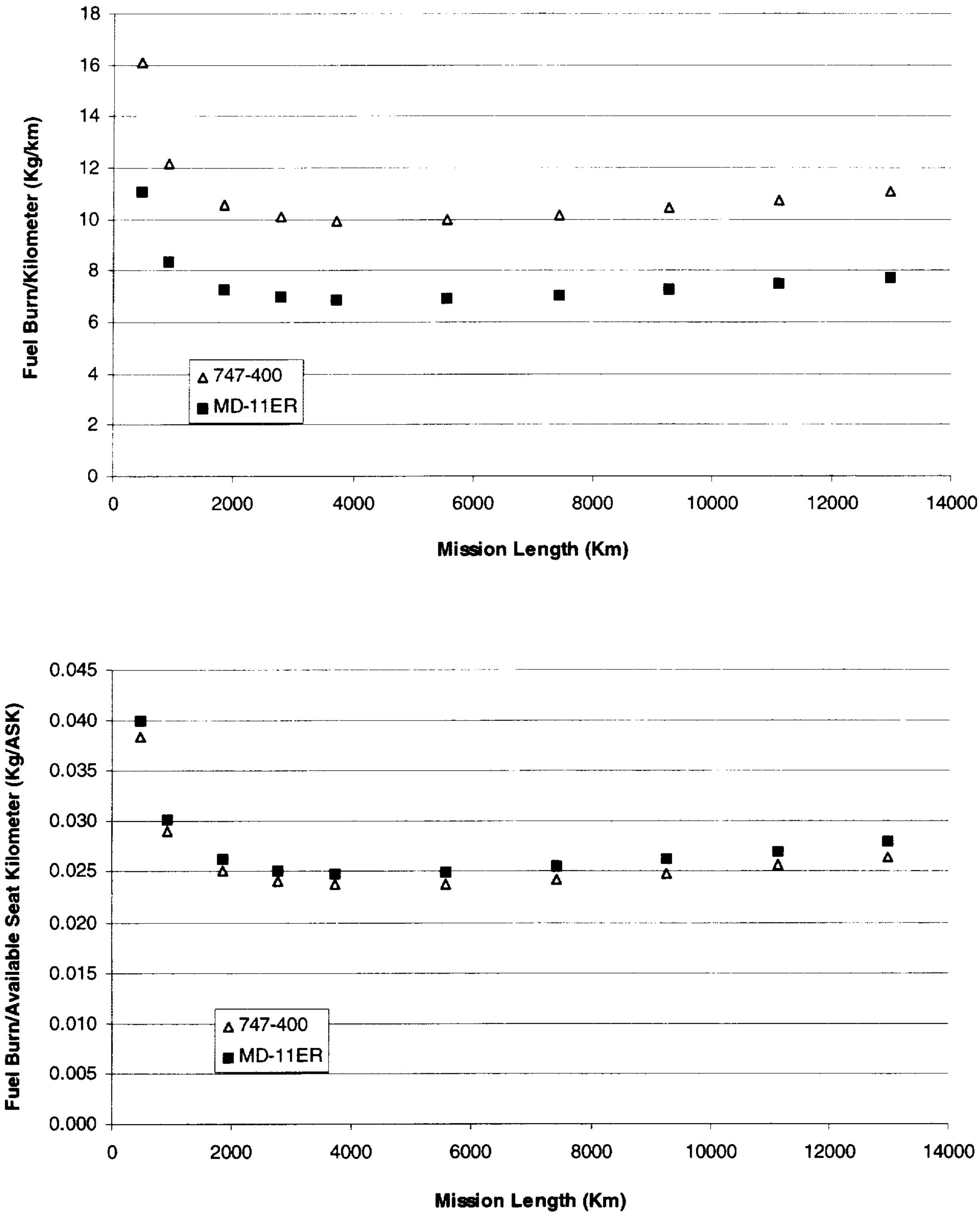


Figure 3-5. Fuel burned per kilometer traveled (top panel) and fuel burned per available seat kilometer traveled (bottom panel) as a function of mission length for the 747-400 and the MD-11ER.

3.3 Seasonal Variability

There is a noticeable- seasonal variation in air traffic departures in some regions as airlines shift schedules and aircraft to accommodate passenger demand. For example, increased air traffic may mean that airlines will utilize their aircraft more frequently and that some airplanes will be used more than others. There are seasonal variations in emissions which reflect both changes in passenger flow and in the equipment being used.

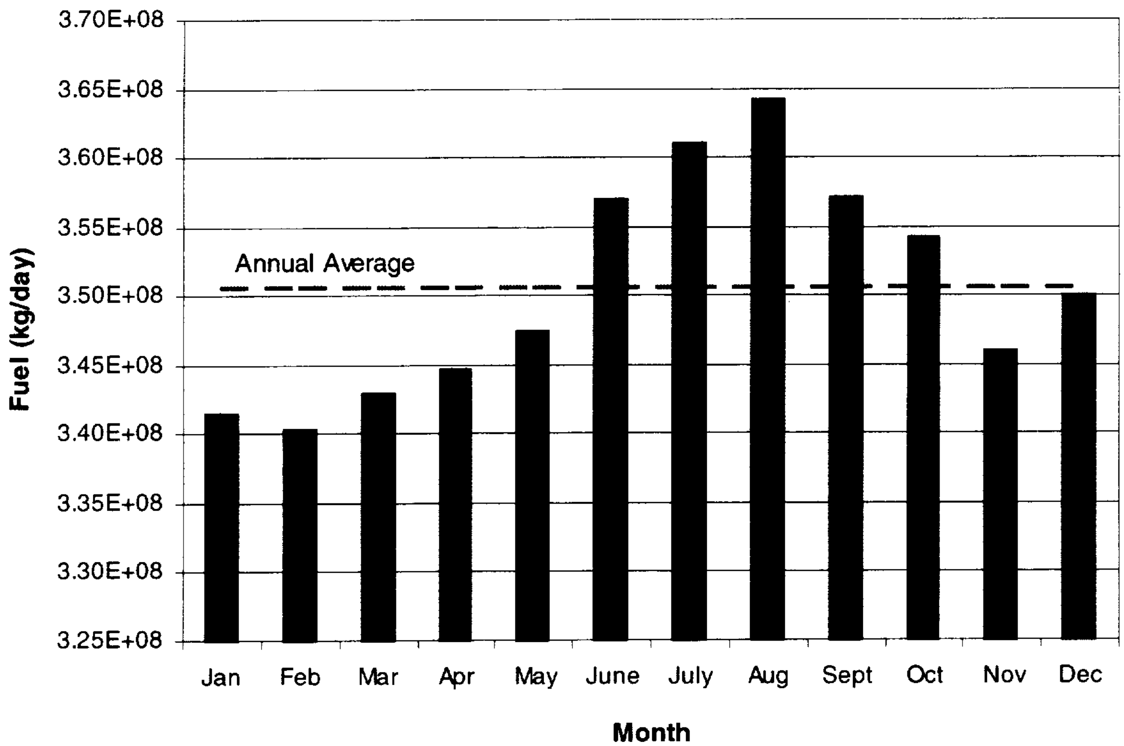
Trends of emissions and fuel burned global totals for the fleet are a composite of three trends: (1) The seasonal variation in traffic demand, (2) Demand growth and changes in overall fleet technology brought about by the introduction of new aircraft and (3) The retirement of old aircraft.

Figure 3-6 shows the seasonal variation in total global fuel burned by the scheduled aircraft fleet (summed over all altitudes). The top panel shows the daily fuel use as a function of month. The bottom panel shows the percent deviation from the annual average fuel use as a function of month. Global fuel use for 1999 peaked at roughly 4% above the annual average in August and was the lowest in February when it was roughly 3% below the annual average. The month having a daily fuel use that was closest to the annual average was December.

Both water vapor and carbon dioxide emission indices are functions of the hydrogen and carbon content, respectively, of the jet fuel. For typical jet fuel,

$EI(H_2O) =$ 1237 grams H_2O/kg fuel burned
$EI\ (CO_2) =$ 3155 grams CO_2/kg fuel burned

Thus, the seasonal variation in carbon dioxide and water vapor emissions from the commercial fleet will be the same as that shown for the fuel usage in Figure 3-6.



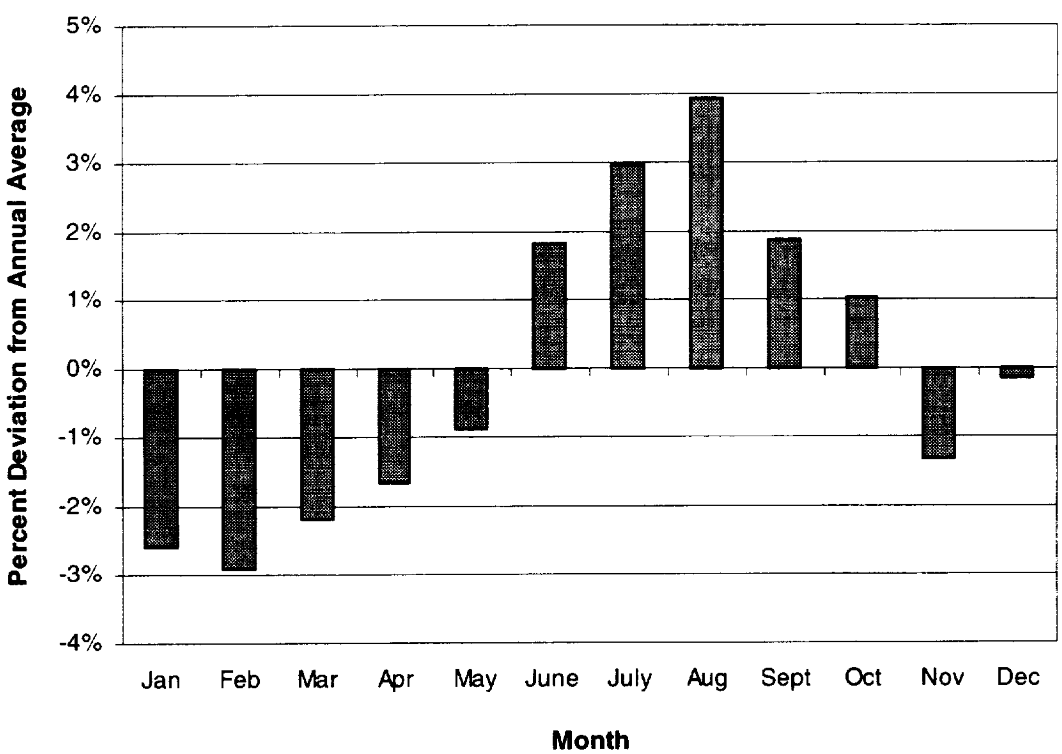


Figure 3-6. Global fuel burned in the 0-19 km altitude band for scheduled air traffic and percent deviation from the annual average fuel burn for each month of 1999.

3.4 *Trend Analysis*

In order to assess changes in scheduled fleet global emissions and fuel burned between 1992 and 1999, August 1999 emission inventory global totals were compared to August 1992 emission inventory global totals calculated using the same updated methodology outlined in Section 2 of this report.

Table 3-6 shows a comparison between the scheduled fleet global emissions, distance and fuel burned totals for August 1992 and August 1999 that were calculated using the same methodology. Both the total change in emissions, distance and fuel burned over the seven year period and the yearly rate of change are given in Table 3-6. Yearly rate of change values were calculated by assuming exponential growth.

Table 3-6. Fuel burned and emissions calculated self-consistently for the scheduled aircraft fleet for August 1992 and August 1999.

	Fuel (kg/day)	NOx (kg/day)	HC (kg/day)	CO (kg/day)	Distance (km/day)
August 1992	2.74E+08	3.57E+06	6.63E+05	1.71E+06	5.07E+07
August 1999	3.64E+08	4.80E+06	5.36E+05	1.94E+06	7.36E+07
Total Change (1992 to 1999)	**33%**	**35%**	**-19%**	**14%**	**45%**
Average Yearly Change	**4.1%**	**4.3%**	**-3.0%**	**1.9%**	**5.5%**

Fuel use was calculated to have increased by 33% between 1992 and 1999, while NOx emissions were calculated to increased by 35%. These increases correspond to an average annual growth rate of approximately 4%. During this same period, the total distance flown by all scheduled aircraft was calculated to increase by 45%, corresponding to an annual growth rate of 5.5%. By contrast, CO emissions were calculated to increase by only 14% and hydrocarbon emissions were calculated to decrease by 19% between 1992 and 1999.

The relatively small yearly growth of CO emissions and the reduction of hydrocarbon emissions between 1992 and 1999 is mainly due to the retirement of old aircraft from the fleet and the delivery of new technology engines as the fleet grew. The new technology engines have more efficient combustors with higher overall pressure ratios (OPR). These engines generally produce less hydrocarbons and CO than the ones they replaced.

The average yearly growth in NOx emissions between August 1992 and August 1999 is slightly larger than that of fuel burned. Higher engine OPRs, although they lead to fuel efficiency improvements, lead to higher temperatures and pressures within the combustor and typically higher NOx emissions for a given combustor design. This tendency presents a challenge to engine manufacturers who are trying to improve engine fuel efficiency while reducing NOx emissions.

Absolute quantities of fleet emissions and fuel burned do not take into account trends of the productivity of the fleet. In order to establish a trend in scheduled fleet global emissions that takes fleet productivity into account, total global NOx emissions and fuel burned for 1992, 1999 and projected emissions and fuel burned for 2015 were normalized by available seat kilometers (ASK) flown and plotted as a function of year in Figure 3-7.

To generate the trends in Figure 3-7, results of the previously published NASA 1992 scheduled fleet global emission inventory (Baughcum, *et al.*, 1996a) were used for the 1992 NOx emissions and fuel burned totals. Results of the previously published NASA 2015 scheduled fleet global emission scenario (Baughcum, et al., 1998) were used for the 2015 NOx emissions and fuel burned totals. As was discussed in Section 2.5, the methodology used to create the NASA 1992 and 2015 inventories was different than that used for the 1999 inventory, but differences in NOx emissions and fuel burned global totals that come about from the use of the two different methodologies are small. Therefore, it is reasonable to use previous NASA calculations of NOx and fuel burned global totals with the current results to develop a trend analysis.

Total ASKs for 1992, 1999 and 2015 were calculated by multiplying average seat counts for each individual aircraft type in the respective inventory by the number of kilometers flown by that aircraft type and adding the ASK totals for all of the individual aircraft types. Total fleet NOx emissions and fuel use were then normalized by these ASK totals

Figure 3-7 shows that both global NOx/ASK and global fuel use/ASK for the scheduled aircraft fleet decrease with time. The dashed trend lines running through the data points in Figure 3-7 represent a 1.2 percent per year improvement and 1.3 percent per year improvement in NOx/ASK and Fuel

Use/ASK, respectively. When the trend lines are extrapolated to 2015, the fuel trend is consistent with the previous 2015 scenario projected, while the NOx trend is slightly better than projected in that scenario.

The trend toward a reduction in NOx/ASK and fuel use/ASK with time demonstrates the effect of introducing improved fuel efficiency and NOx emission reduction technology into the scheduled fleet.

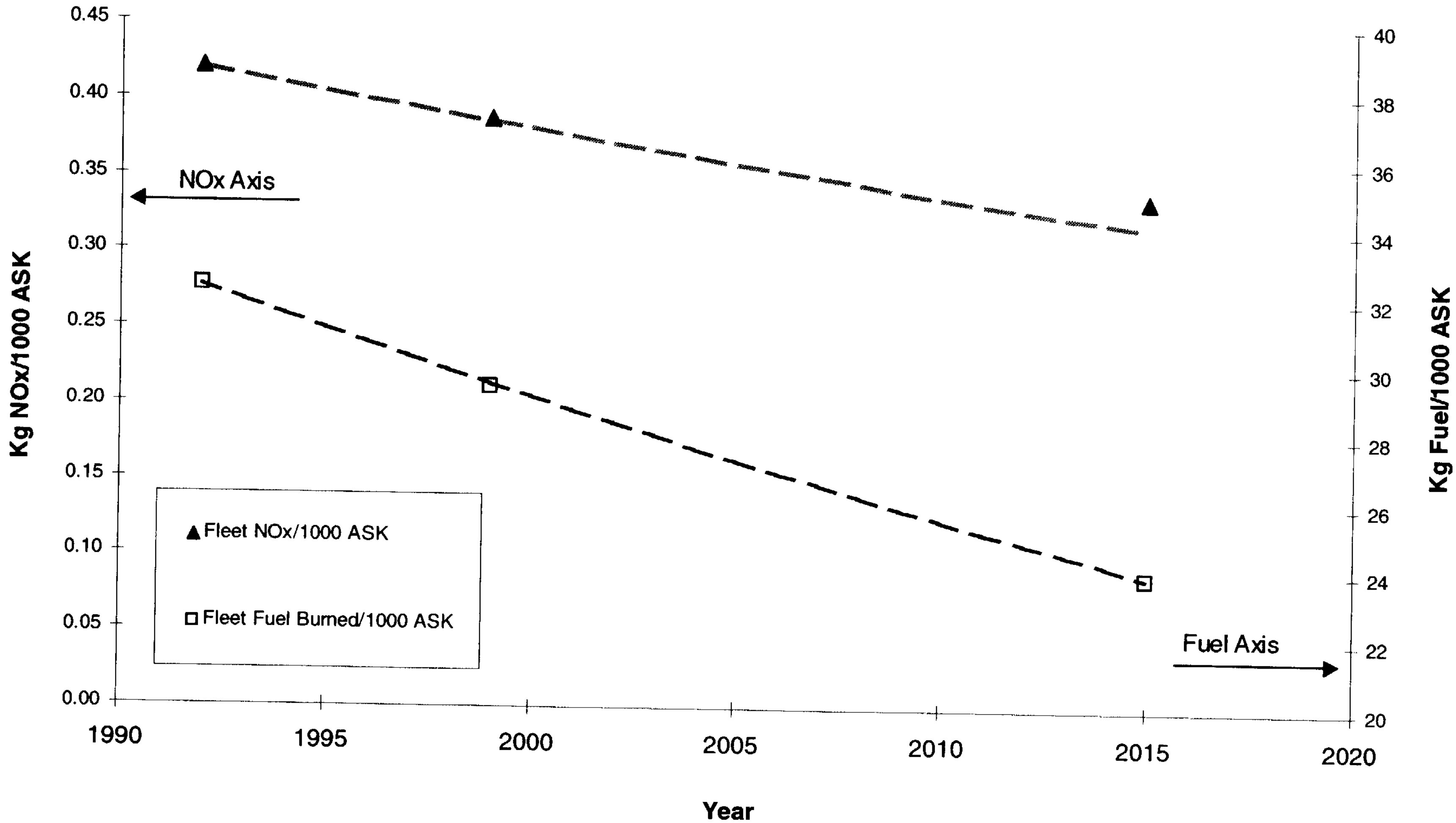


Figure 3-7. Trends of global scheduled fleet NOx/ASK and fuel burned/ASK derived from NASA emission inventory and scenario work.

3.5 Effects of Improved Freighter Modeling

In the earlier NASA emission inventories, (Baughcum, *et al.*, 1996a and 1996b) no distinction was made between flights flown by freighter aircraft and those flown by passenger aircraft. All aircraft flights were modeled using performance data generated assuming a 70% passenger load factor. In the OAG flight schedules created for this study, flights flown by freighters are distinguished from those flown by passenger aircraft. This increased detail in the schedule made it possible in the 1999 inventory calculations to more accurately model freighters by modeling them with more representative payloads.

As described in Section 2.3.3 of this report, DOT Form T-100 data were analyzed to determine average payloads for various types of freighter aircraft. Based on this analysis, it was determined that more accurate inventory results could be obtained if very large freighter aircraft types (747, MD-11, L-1011, DC-10 and Antonov An-124) were modeled using passenger versions with payloads heavier than those associated with 70% passenger loading. This analysis also showed that small and medium freighter aircraft could be modeled accurately enough by using passenger versions with payloads corresponding to 70% passenger load factor as was done in previous NASA inventory calculations.

In order to determine the effect of improved freighter payload assumptions on global fuel burned and NOx totals, inventory calculations were made with and without the improved freighter payload assumptions discussed above for August 1999. For general aircraft types that included very large freighters, Table 3-7 shows fuel burned and NOx emissions global totals for the two different calculations along with percent difference comparisons. A positive percent difference indicates that the new freighter payload assumptions increased fuel burn or NOx emissions. Table 3-7 also shows the percent of the total distance within each aircraft type that was traveled by freighter aircraft.

Total fuel use and NOx for the 1999 scheduled aircraft fleet were increased by 0.6 and 1.5 percent respectively when the improved freighter payload assumptions were used. For each aircraft type modeled using improved payload assumptions, global NOx emissions and fuel use increased because the aircraft operated at higher takeoff gross weights (TOGW). Higher TOGWs require higher engine thrust throughout the mission. This leads to increased fuel burn and higher combustor temperatures, which in turn lead to increased NOx emissions.

This improved treatment of freighter aircraft represents a fairly small correction to the emission inventories.

Table 3-7. Comparison of August 1999 global fuel burned and NOx emissions with and without the use of freighter cargo loading assumptions.

General Aircraft Type	Percent of General Type Distance Traveled by Freighters	Fuel Burned			NOx Emissions		
		With Freighter Payloads (kg/day)	Without Freighter Payloads (kg/day)	Percent Difference	With Freighter Payloads (kg/day)	Without Freighter Payloads (kg/day)	Percent Difference
Boeing 747-100/200/300	41.7%	2.88E+07	2.74E+07	5.3%	4.83E+05	4.34E+05	11.3%
Boeing 747-400	3.7%	6.46E+07	6.44E+07	0.4%	9.30E+05	9.25E+05	0.6%
DC-10	9.8%	1.38E+07	1.37E+07	1.1%	2.21E+05	2.17E+05	2.0%
Lockheed L-1011	4.5%	2.56E+06	2.55E+06	0.4%	3.99E+04	3.96E+04	0.6%
MD-11	23.5%	1.29E+07	1.24E+07	4.0%	1.74E+05	1.65E+05	5.9%
Russian Aircraft	4.4%	8.10E+06	8.09E+06	0.1%	7.86E+04	7.85E+04	0.1%
Global Totals		**3.65E+08**	**3.62E+08**	**0.6%**	**4.80E+06**	**4.73E+06**	**1.5%**

3.6 Database Availability

The 3-dimensional scheduled aircraft emission inventories of fuel burned and emissions calculated on a 1 degree latitude x 1 degree longitude x 1 km altitude grid for each month of 1999 and for August 1992 have been delivered in electronic format to the NASA Langley Research Center. Questions concerning the availability of these data should be directed to Dr. Chowen C. Wey (Chowen.C.Wey@grc.nasa.gov), the NASA GRC contract monitor for this work. Technical questions about the data set should be sent to Steven L. Baughcum (Steven.L.Baughcum@boeing.com) or Donald J. Sutkus (Donald.J.Sutkus@boeing.com) at the Boeing Company, P. O. Box 3707, MS 0R-RC, Seattle, WA 98124-2207.

4. Comparison of 1999 Inventory Results with DOT Form 41 Data

As discussed in Section 2 of this report, the 1999 scheduled aircraft fleet global emission inventory was created using Official Airline Guide (OAG) flight schedule data, Boeing aircraft performance data and International Civil Aviation Organization (ICAO) engine emissions data.

In developing the performance data used to model aircraft in the 1999 scheduled aircraft fleet global emission inventory, certain simplifying assumptions were made about the conditions under which aircraft operate. These assumptions, which are listed below, lead to errors in the calculation of global aircraft fleet fuel burned and emissions. These errors have been discussed in detail in previous work (Baughcum, *et al.*, 1996a; Daggett, *et al.*, 1999).

Performance Assumptions for the NASA 1999 scheduled emission inventory calculations:

- No winds
- International Standard Atmosphere (ISA) temperatures and pressures
- Continuous climb cruise flight segment with typical westbound flight beginning and ending cruise altitudes
- All aircraft were modeled as passenger aircraft except 747, MD-11, DC-10, L-1011 and An-124 freighter aircraft which were modeled using typical freighter cargoes and OEWs
- Passenger aircraft were modeled assuming no cargo (Payload = passengers + baggage weight)
- Passenger aircraft were modeled using a 70% passenger load factor
- Passenger and baggage weight were assumed to be 200 lb/passenger for single aisle and 210 lb/passenger for wide body aircraft
- Boeing typical weight calculations were used for Operating Empty Weight, Maximum Landing Weight, Maximum Zero Fuel Weight, etc.
- Fuel density of 6.75 lb/gallon and fuel energy content of 18,580 BTU/lb
- Direct great circle routes--no turns or air traffic control diversions
- Takeoff Gross Weights (TOGW) are calculated assuming city pairs are at sea level. Performance calculations assume origin and destination airports are at their respective actual airport altitudes.
- Optimum aircraft operating rules
- Engine and airframe performance at new airplane level

Some of the characteristics of the OAG flight schedule data used in creating the scheduled aircraft fleet emission inventories also lead to inaccuracies in global aircraft emission inventory calculations. As discussed in

Section 2 of this report, the 1999 scheduled aircraft fleet global emission inventory calculations are based on the OAG listing of flights which is used as a resource for travelers attempting to book flights. Flights listed in the OAG are those that are *projected* to take place and not ones that necessarily occurred. In addition, the OAG flight schedule often contains duplicate listings of the same flights due to phenomena such as codesharing between airlines. Filtering of the OAG schedules must be done prior to their use for calculating emission inventories and the filtering process is another possible source for inaccuracies in emission inventory results.

In order to evaluate the 1999 scheduled aircraft fleet global emission inventory calculations, comparisons were made between results of these calculations and aviation fuel use and traffic data reported on the U.S. Department of Transportation (DOT) Form 41. Details of this comparison are discussed below.

Each large U.S. air carrier must report statistics for aircraft fuel used, revenue aircraft departures performed and revenue aircraft statute ground track miles flown during a given year on U.S. DOT Form 41. A more detailed description of DOT Form 41 data is contained in previous work (Daggett, *et al.*, 1999). Although these statistics are reported by specific aircraft type (i.e. 747, DC-10 etc.) and geographic region (i.e. North America, Atlantic Ocean, etc.), only airline totals were compared with 1999 scheduled emission inventory results.

DOT Form 41 fuel issue, departure and ground track miles flown data were obtained for the 1999 calendar year for each carrier that reported traffic and capacity data to the U.S. Department of Transportation. Results of the 1999 scheduled aircraft emission inventory calculations were compared to these data. Comparisons were made for the ten passenger airlines that burned the most fuel in 1999 (according to the DOT data) and for the four major cargo carriers that report their fuel use and air traffic statistics to the DOT. The ten passenger airlines considered reported 87% of all fuel use reported by passenger carriers included in the DOT Form 41 database. The four cargo airlines considered account for 87% of all carrier cargo fuel use and approximately 10% of total fuel use reported on DOT Form 41 by all US carriers (passenger and cargo).

Table 4-1. By airline comparison of DOT Form 41 reported departures, distance and fuel burned with 1999 scheduled inventory global totals for selected passenger carriers.

Air Carrier	Departures/Year			Distance/Year (km)			Fuel Burned/Year (Kg)		
	DOT	Inventory	% Diff.	DOT	Inventory	% Diff.	DOT	Inventory	% Diff.
United Air Lines	8.20E+05	8.59E+05	5%	1.06E+09	1.10E+09	4%	9.38E+09	7.68E+09	-18%
USAir	7.11E+05	6.84E+05	-4%	5.04E+08	5.26E+08	4%	3.38E+09	2.70E+09	-20%
America West Airlines	2.10E+05	2.17E+05	3%	2.09E+08	2.16E+08	4%	1.26E+09	9.81E+08	-22%
American Airlines	8.18E+05	8.45E+05	3%	1.13E+09	1.16E+09	2%	8.88E+09	7.10E+09	-20%
Alaska Airlines	1.70E+05	1.75E+05	3%	1.50E+08	1.55E+08	3%	9.37E+08	7.52E+08	-20%
Delta Air Lines	9.58E+05	9.32E+05	-3%	9.37E+08	9.44E+08	1%	8.33E+09	6.55E+09	-21%
Northwest Airlines	5.85E+05	6.00E+05	3%	6.09E+08	6.19E+08	2%	6.24E+09	4.96E+09	-21%
Southwest Airlines	8.48E+05	8.59E+05	1%	4.54E+08	4.60E+08	1%	2.84E+09	2.27E+09	-20%
Trans World Airlines	2.87E+05	2.91E+05	1%	2.78E+08	2.78E+08	0%	2.09E+09	1.61E+09	-23%
Continental	4.82E+05	4.78E+05	-1%	6.18E+08	6.11E+08	-1%	4.85E+09	3.49E+09	-28%
Passenger Carrier Totals	**5.89E+06**	**5.94E+06**	**1%**	**5.95E+09**	**6.07E+09**	**2%**	**4.82E+10**	**3.81E+10**	**-21%**

Table 4-2. By airline comparison of DOT Form 41 reported departures, distance and fuel burned with 1999 scheduled inventory global totals for selected cargo carriers.

Air Carrier	Departures/Year			Distance/Year (km)			Fuel Burned/Year (Kg)		
	DOT	Inventory	% Diff.	DOT	Inventory	% Diff.	DOT	Inventory	% Diff.
Federal Express	3.36E+05	5.07E+04	-85%	2.39E+08	9.02E+07	-62%	2.58E+09	1.02E+09	-60%
Emery Worldwide	7.48E+04	4.26E+04	-43%	8.38E+07	4.10E+07	-51%	6.18E+08	3.60E+08	-42%
DHL Airways	7.83E+04	5.22E+04	-33%	3.78E+07	3.18E+07	-16%	2.88E+08	1.99E+08	-31%
United Parcel Service	1.33E+05	1.26E+05	-5%	1.49E+08	1.29E+08	-13%	1.57E+09	1.12E+09	-29%
Cargo Carrier Totals	**6.22E+05**	**2.71E+05**	**-56%**	**5.09E+08**	**2.92E+08**	**-43%**	**5.06E+09**	**2.69E+09**	**-47%**

Table 4-1 shows the results of the comparison of yearly totals for departures, distance traveled and fuel burned for the ten passenger carriers considered. Comparisons are made on a percent difference basis relative to the DOT Form 41 reported values. A negative percent difference denotes that 1999 emission inventory values are lower than those reported on DOT Form 41.

Table 4-1 shows that total departures and distance flown agree within 5 percent for all of the ten passenger air carriers considered with the differences in total departures and distance traveled for the ten passenger carriers being 1 percent and 2 percent respectively. The agreement for total departures and distance traveled is reasonably good considering that the OAG schedule data used to calculate the 1999 emission inventory is based on projections of air traffic demand. Both flight cancellations and code sharing between airlines or their subsidiaries will contribute to the differences.

Because total departures and distance traveled are in relatively good agreement, comparisons of fuel burned between the two data sets may be used to give an indication of how well the emission inventory calculations predicted fuel burned for the ten passenger airlines considered. For the passenger air carriers listed in Table 4-1, the inventory calculations under predicted total fuel by 21 percent on average. The differences in fuel burned for passenger carriers are similar to those found in a similar analysis of 1992 scheduled aircraft emission inventory results (Daggett, *et al*, 1999). The majority of these differences are likely due to the simplifying assumptions made regarding the performance calculations used in creating the emission inventory. Major factors here are the effect of air traffic control, the effect of weather and winds, assumed payload, cargo load, and the assumption of great circle routing between airports.

Table 4-2 shows the results of the comparison of yearly totals for departures, distance traveled and fuel burned for the four cargo carriers considered in this analysis. This table shows that, for the four cargo carriers considered, the total departures and total distance traveled calculated in the 1999 scheduled aircraft emission inventory are significantly less than those reported in the DOT Form 41 data. The inventory under predicts total departures and distance traveled by 56 percent and 43 percent respectively on average. This indicates that the OAG flight schedule data used to create the 1999 scheduled aircraft fleet emission inventory do not contain a complete listing of flights flown by cargo carriers. Fuel use by these four selected cargo carriers was under predicted by 47 percent on average. Similar behavior was observed for DOT Form 41 comparisons made for 1992 emission inventory results (Daggett, *et al*, 1999).

To put the under prediction of cargo flights in perspective, the fuel use reported on DOT Form 41 by all cargo carriers for 1999 was approximately 10 percent of the fuel use reported by all carriers (passenger and cargo). Thus, missing the cargo carrier fuel use by approximately 50 percent in the emission inventory would correspond to an error of approximately 5 percent in the calculated fuel use by all US carriers.

Although this percentage may not necessarily be representative for non-U.S. carriers, it is large enough to justify further investigation of the effect that the lack of coverage of cargo flights in the OAG has on global emission inventory calculations. An investigation of this type is not within the scope of the current work but should be considered for future study.

Overall, this comparison indicates that the OAG data are relatively complete, at least for US carriers, but that there is a systematic under prediction of fuel use of approximately 21 percent in the emission inventories. For cargo carriers, the comparison indicates that there is a systematic under counting of cargo flights in the OAG data with which we are working. This would introduce an additional 5 percent under prediction in the inventory calculations of US carriers. It is unclear how to extend these results to global totals or how to account for them explicitly in the 3-dimensional emission inventory calculation.

5. Summary and Conclusions

Emissions produced by the world's entire aircraft fleet come from scheduled, military, charter and general aviation air traffic. In this report, we only present the results and methodology used for the calculation of emissions from scheduled air traffic which includes turboprops, passenger jets, and jet cargo aircraft.

Global fuel use for 1999 by scheduled air traffic was calculated to be 1.28×10^{11} kilograms. Global NOx emissions by scheduled air traffic in 1999 were calculated to be 1.69×10^{9} kilograms (as NO_2). The calculated global emissions show a seasonal variation, peaking in August with a minimum in February. Emissions for the month of December 1999 were closest to global annual average emissions, although emissions for May (the month typically used as an 'average' month in past NASA inventory studies) were within 1 percent of the global annual average.

A trend analysis for emissions and fuel burned was performed using the results of this current work and previously published emission inventories and scenarios. This analysis showed an increase in the absolute amount of fuel burned, distance traveled, NOx, and CO emissions produced by the scheduled fleet between 1992 and 1999 and a decrease in the absolute amount of hydrocarbon emissions produced. Calculated global fuel use increased by 33% and NOx emissions increased by 35% between 1992 and 1999. The analysis also showed that scheduled fleet fuel burned and NOx emissions normalized by available seat kilometers decreased between 1992 and 2015.

The methodology used to extract and process air traffic data from the Official Airline Guide was changed from that used to calculate previous scheduled fleet inventories for 1976, 1984 and 1992. To quantify the effects of the methodology changes, an emission inventory for August 1992 was recalculated using the new methodology. Comparisons between the previously published and new August 1992 inventories show good agreement for global fuel burned and NOx totals. For CO and hydrocarbons, the global totals increased by 20 percent and 18 percent respectively with the use of the new methodology. Much of this difference arises from the different combustor types selected in the two methodologies for certain engines in the fleet. Emissions from a specific engine model can vary widely depending on the combustor that is installed in the engine.

To improve the accuracy of global emissions calculations for freighters, United States Department of Transportation Form T-100 data were used to determine typical payloads for freighter aircraft. This information was then used to model freighter aircraft more accurately in the inventory calculations by using more realistic payloads.

To assess the effect of the different freighter payload assumptions, results were compared with previous inventory calculations done using 70 percent passenger payload for all aircraft. This comparison showed that improved freighter payload assumptions increased total global fuel burned by 0.6 percent and increased total global NOx by 1.5 percent for August 1999. These increases are relatively small and will not significantly change trends for fuel use or NOx created using the published inventories for 1976, 1984, and 1992.

In order to evaluate the 1999 scheduled aircraft fleet global emission inventory calculations, comparisons were made with aviation fuel use and traffic data reported on the U.S. Department of Transportation (DOT) Form 41 by US air carriers. In general, emission inventory calculations of departures and distance traveled for 1999 compared well (within 5 percent) with the DOT Form 41 data for the ten largest passenger carriers. In contrast, for the four largest cargo carriers, departures and distance traveled calculated were significantly less than those reported on DOT Form 41. It appears that the OAG flight schedule data do not contain a complete listing of cargo flights.

For the passenger carriers in the DOT Form 41 data comparison, the emission inventory calculations consistently under-predicted fleet fuel burned. The magnitude of these under-predictions varied depending on the carrier being considered. For the ten largest air carriers, the total fuel burn was under-predicted by 21 percent. This result is likely due to the simplifying assumptions used in the development of the global inventory, including our inability to consider air traffic control delays/diversions, weather/wind factors, more realistic routing, less than optimum aircraft/engine performance and actual aircraft operating weights.

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Appendix A – Sample Airclaims Fleet Information Data

This Appendix contains a sample of the fleet information obtained from the Airclaims database that was used to assign engines to aircraft listed in the filtered OAG flight schedule. The sample data in this appendix show the Japan Airlines fleet as it existed on May 16, 1999.

Appendix A – Sample Airclaims Fleet Information Data

Carrier Name	Carrier Code	Aircraft Type	Aircraft Variant	Aircraft Usage	Engine Type	Engine Variant	Aircraft in Service
Japan Airlines	JAL	737 (CFMI)	400	All Passenger	CFM56	3C1	4
Japan Airlines	JAL	747	100	All Passenger	JT9D	7A	2
		747	100B/SR (SUD) (P&W)	All Passenger	JT9D	7A	2
		747	100B/SR (P&W)	All Passenger	JT9D	7A	1
Japan Airlines	JAL	747	200B (P&W)	All Passenger	JT9D	7Q	6
		747	200B (P&W)	All Passenger	JT9D	7A	5
		747	200B (P&W)	All Passenger	JT9D	7R4G2	3
		747	200B (P&W)	All Passenger	JT9D	7AW	2
		747	200F (SCD) (P&W)	All Freight / Cargo	JT9D	7Q	4
		747	200F (SCD) (P&W)	All Freight / Cargo	JT9D	7R4G2	2
		747	200F (P&W)	All Freight / Cargo	JT9D	7Q	1
		747	200F (SCD) (P&W)	All Freight / Cargo	JT9D	7AW	1
		747	200SF (P&W)	All Freight / Cargo	JT9D	7Q	1
Japan Airlines	JAL	747	300 (P&W)	All Passenger	JT9D	7R4G2	11
Japan Airlines	JAL	747	400 (GE)	All Passenger	CF6	80C2B1F	29
		747	400D (GE)	All Passenger	CF6	80C2B1F	8
Japan Airlines	JAL	767	200 (P&W)	All Passenger	JT9D	7R4D	3
Japan Airlines	JAL	767	300 (P&W)	All Passenger	JT9D	7R4D	12
		767	300 (GE)	All Passenger	CF6	80C2B4F	4
		767	300 (GE)	All Passenger	CF6	80C2B2	1
Japan Airlines	JAL	777	200 (P&W)	All Passenger	PW4000	4077	5
Japan Airlines	JAL	777	300 (P&W)	All Passenger	PW4000	4090	4
Japan Airlines	JAL	DC-10	40I	All Passenger	JT9D	59A	9
		DC-10	40D	All Passenger	JT9D	59A	4
Japan Airlines	JAL	MD-11	Passenger (P&W)	All Passenger	PW4000	4460	10

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

This Appendix contains a list of each aircraft/engine combination listed in the filtered OAG flight schedule and the performance aircraft and emissions engine that was used to model it. Each emissions engine name has a prefix that represents its unique ID number in the ICAO Engine Emissions Databank. Some emissions data used in the creation of the 1999 inventory had not been published as of the writing of this report and was obtained directly from the engine companies. These emissions engines are listed with the internal Boeing prefix of the form "PREXXX_".

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
100-*	RB.183-620-15	FOKKER-100	TAY-650	1RR020_TAYMk620-15
100-*	RB.183-650-15	FOKKER-100	TAY-650	1RR021_TAYMk650-15
146-100	ALF502-R-5	BAE146-200	ALF502R-5	1TL003_ALF502R-5
146-200	ALF502-R-5	BAE146-200	ALF502R-5	1TL003_ALF502R-5
146-300	ALF502-R-5	BAE146-200	ALF502R-5	1TL003_ALF502R-5
146-300	LF507-1H	RJ-100	LF507	1TL004_LF507-1F-1H
146-300QT_FRT	ALF502-R-5	BAE146-300	ALF502R-5	1TL003_ALF502R-5
318	Blank-Blank	737-500	CFM56-3-B1-18.5	1CM004_CFM56-3-B1
70-*	RB.183-620-15	FOKKER-70	MARK-620-15	1RR020_TAYMk620-15
707-320C	JT3D-3B	707-320B-C	JT3D-3B	1PW001_JT3D-3B
707-320C_All_FRT	JT3D-3B	707-320B-C	JT3D-3B	1PW001_JT3D-3B
707-320C_All_FRT	JT3D-7	707-320B-C	JT3D-3B	1PW001_JT3D-3B
707-320C_FRT	JT3D-3B	707-320B-C	JT3D-3B	1PW001_JT3D-3B
707-320C_FRT	JT3D-7	707-320B-C	JT3D-3B	1PW001_JT3D-3B
70M	Blank-Blank	707-320B-C	JT3D-3B	1PW004_JT8D-7series
717-200	BR700-715C	MD-95-30	BR715	4BR005_BR700-715A1-30
721	Blank-Blank	727-100	JT8D-7	1PW004_JT8D-7series
727-100	JT8D-7	727-100	JT8D-7	1PW004_JT8D-7series
727-100	JT8D-7B	727-100	JT8D-7	1PW004_JT8D-7series
727-100	JT8D-9	727-100	JT8D-9	1PW006_JT8D-9series
727-100	JT8D-9A	727-100	JT8D-9	1PW006_JT8D-9series
727-100C	JT8D-9	727-100	JT8D-9	1PW006_JT8D-9series
727-100C_CMB	JT8D-7	727-100	JT8D-7	1PW004_JT8D-7series
727-100C_CMB	JT8D-7B	727-100	JT8D-7	1PW004_JT8D-7series
727-100C_FRT	JT8D-7	727-100	JT8D-7	1PW004_JT8D-7series
727-100F_FRT	JT8D-7B	727-100	JT8D-7	1PW004_JT8D-7series
727-100F_FRT	JT8D-9	727-100	JT8D-9	1PW006_JT8D-9series
727-100QC_FRT	JT8D-9A	727-100	JT8D-9	1PW006_JT8D-9series
727-100QF_FRT	RB.183-651-54	727-100	JT8D-7	1PW004_JT8D-7series
727-200	JT8D-15	727-200	JT8D-15-15A	1PW009_JT8D-15

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
727-200	JT8D-17	727-200	JT8D-15-15A	1PW012_JT8D-17
727-200	JT8D-17A	727-200	JT8D-15-15A	1PW010_JT8D-15
727-200	JT8D-17R	727-200	JT8D-15-15A	1PW016_JT8D-17R
727-200	JT8D-7B	727-200	JT8D-9	1PW004_JT8D-7series
727-200	JT8D-9	727-200	JT8D-9	1PW006_JT8D-9series
727-200	JT8D-9A	727-200	JT8D-9	1PW006_JT8D-9series
727-200F_FRT	JT8D-15	727-200	JT8D-15-15A	1PW009_JT8D-15
727-200F_FRT	JT8D-17	727-200	JT8D-15-15A	1PW012_JT8D-17
727-200F_FRT	JT8D-17R	727-200F	JT8D-15-15A	1PW016_JT8D-17R
727-200F_FRT	JT8D-7	727-200	JT8D-9	1PW006_JT8D-9series
727-200F_FRT	JT8D-9	727-200	JT8D-9	1PW006_JT8D-9series
727-200RE	JT8D-Two_-217C	727-200	JT8D-9	1PW006_JT8D-9series
731	Blank-Blank	737-100	JT8D-9	1PW006_JT8D-9series
737-100	JT8D-7A	737-100	JT8D-9	1PW016_JT8D-17R
737-200	JT8D-15	737-200	JT8D-15	1PW009_JT8D-15
737-200	JT8D-15A	737-200	JT8D-15	1PW011_JT8D-15A
737-200	JT8D-17	737-200	JT8D-15	1PW012_JT8D-17
737-200	JT8D-17A	737-200	JT8D-15	1PW014_JT8D-17A
737-200	JT8D-7	737-200	JT8D-7	1PW004_JT8D-7series
737-200	JT8D-9	737-200ADV	JT8D-9-9A	1PW006_JT8D-9series
737-200	JT8D-9A	737-200ADV	JT8D-9-9A	1PW006_JT8D-9series
737-200C	JT8D-15	737-200	JT8D-15	1PW009_JT8D-15
737-200C	JT8D-17	737-200	JT8D-15	1PW012_JT8D-17
737-200C	JT8D-17A	737-200	JT8D-15	1PW014_JT8D-17A
737-200C	JT8D-9A	737-200ADV	JT8D-9-9A	1PW006_JT8D-9series
737-200C_CMB	JT8D-17	737-200	JT8D-15	1PW012_JT8D-17
737-200C_CMB	JT8D-9A	737-200ADV	JT8D-9-9A	1PW006_JT8D-9series
737-200C_QC	JT8D-15	737-200	JT8D-15	1PW009_JT8D-15

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
737-200C_QC	JT8D-15A	737-200	JT8D-15	1PW011_JT8D-15A
737-200C_QC	JT8D-17A	737-200	JT8D-15	1PW014_JT8D-17A
737-200C_QC	JT8D-9	737-200	JT8D-7	1PW006_JT8D-9series
737-200QC	JT8D-9A	737-200	JT8D-7	1PW006_JT8D-9series
737-200QC_FRT	JT8D-15	737-200	JT8D-15	1PW009_JT8D-15
737-200QC_FRT	JT8D-9A	737-200ADV	JT8D-9-9A	1PW006_JT8D-9series
737-200QC_QC	JT8D-9A	737-200ADV	JT8D-9-9A	1PW006_JT8D-9series
737-300	CFM56-3B1	737-300	CFM56-3-B1	1CM004_CFM56-3-B1
737-300	CFM56-3B2	737-300	CFM56-3-B1	1CM004_CFM56-3-B1
737-300	CFM56-3C1	737-300	CFM56-3-B1	1CM004_CFM56-3-B1
737-300QC_QC	CFM56-3C1	737-300	CFM56-3-B1	1CM004_CFM56-3-B1
737-400	CFM56-3B2	737-300	CFM56-3-B1	1CM005_CFM56-3B-2
737-400	CFM56-3C1	737-300	CFM56-3-B1	1CM005_CFM56-3B-2
737-500	CFM56-3B1	737-500	CFM56-3-B1-18.5	1CM007_CFM56-3C-1
737-500	CFM56-3C1	737-500	CFM56-3-B1-18.5	1CM007_CFM56-3C-1
737-600	CFM56-7B20	737-600	CFM56-7B18	3CM029_CFM56-7B18
737-700	CFM56-7B22	737-700	CFM56-7B20	3CM030_CFM56-7B20
737-700	CFM56-7B24	737-700	CFM56-7B20	3CM030_CFM56-7B20
737-800	CFM56-7B24	737-800	CFM56-7B24	3CM032_CFM56-7B24
737-800	CFM56-7B26	737-800	CFM56-7B27	3CM034_CFM56-7B27
737-800	CFM56-7B27	737-800	CFM56-7B27	3CM034_CFM56-7B27
747-100	JT9D-7	747-100-200	JT9D-7A	1PW021_JT9D-7A
747-100	JT9D-7A	747-100-200	JT9D-7A	1PW021_JT9D-7A
747-100B	RB211-524C2	747-200	RB211-524C	1RR006_RB211-524C2
747-100B_SR	JT9D-7A	747-100-200	JT9D-7A	1PW021_JT9D-7A
747-100F_FRT	JT9D-7A	747-100F	JT9D-7F	1PW021_JT9D-7A
747-200B	CF6-50E2	747-100-200	CF6-50E2	1GE009_CF6-50E2
747-200B	JT9D-70A	747-100-200	JT9D-7A	1PW021_JT9D-7A

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
747-200B	JT9D-7A	747-100-200	JT9D-7A	1PW021_JT9D-7A
747-200B	JT9D-7AW	747-100-200	JT9D-7A	1PW021_JT9D-7A
747-200B	JT9D-7F	747-200	JT9D-7J	1PW023_JT9D-7F
747-200B	JT9D-7J	747-200	JT9D-7J	1PW024_JT9D-7J
747-200B	JT9D-7Q	747-200B-C-F	JT9D-7Q	1PW025_JT9D-7Q
747-200B	JT9D-7Q3	747-200B-C-F	JT9D-7Q	1PW025_JT9D-7Q
747-200B	JT9D-7R4G2	747-200	JT9D-7R4G2	1PW029_JT9D-7R4G2
747-200B	RB211-524D4	747-200	RB211-524D4U	1RR007_RB211-524D4
747-200B_CMB	CF6-50E	747-100-200	CF6-50E2	1GE009_CF6-50E2
747-200B_CMB	CF6-50E2	747-100-200	CF6-50E2	1GE009_CF6-50E2
747-200B_CMB	JT9D-7Q	747-200B-C-F	JT9D-7Q	1PW025_JT9D-7Q
747-200C_F_FRT	CF6-50E2	747-300F	CF6-50E2	1GE009_CF6-50E2
747-200C_QC	CF6-50E2	747-100-200	CF6-50E2	1GE009_CF6-50E2
747-200F_FRT	CF6-50E2	747-300F	CF6-50E2	1GE009_CF6-50E2
747-200F_FRT	JT9D-7F	747-200F	JT9D-7J	1PW024_JT9D-7J
747-200F_FRT	JT9D-7J	747-200F	JT9D-7J	1PW024_JT9D-7J
747-200F_FRT	JT9D-7Q	747-200F	JT9D-7J	1PW024_JT9D-7J
747-200F_FRT	JT9D-7R4G2	747-200F	JT9D-7J	1PW024_JT9D-7J
747-200F_FRT	RB211-524D4	747-200F	RB211-524D4	1RR008_RB211-524D4
747-200SF_FRT	CF6-50E2	747-300F	CF6-50E2	1GE009_CF6-50E2
747-200SF_FRT	JT9D-7J	747-200F	JT9D-7J	1PW024_JT9D-7J
747-200SF_FRT	JT9D-7Q	747-200F	JT9D-7J	1PW024_JT9D-7J
747-200SF_FRT	JT9D-7R4G2	747-200F	JT9D-7J	1PW024_JT9D-7J
747-200SF_FRT	RB211-524D4	747-200F	RB211-524D4	1RR007_RB211-524D4
747-300	CF6-50E2	747-300	CF6-50E2	1GE009_CF6-50E2
747-300	CF6-80C2B1	747-300	CF6-80C2B1	1GE022_CF6-80C2B1
747-300	JT9D-7R4G2	747-300	JT9D-7R4G2	1PW029_JT9D-7R4G2
747-300	RB211-524C2	747-300	RB211-524D4UP	1RR008_RB211-524D4

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
747-300	RB211-524D4	747-300	RB211-524D4UP	1RR007_RB211-524D4
747-300_CMB	CF6-50E2	747-300	CF6-50E2	1GE009_CF6-50E2
747-300_CMB	CF6-80C2B1	747-300	CF6-80C2B1	1GE022_CF6-80C2B1
747-300_CMB	JT9D-7R4G2	747-300	JT9D-7R4G2	1PW029_JT9D-7R4G2
747-300_SR	JT9D-7R4G2	747-300	JT9D-7R4G2	1PW029_JT9D-7R4G2
747-400	CF6-80C2B1F	747-400	CF6-80C2-B1F	1GE024_CF6-80C2B1F
747-400	PW4000-4056	747-400	PW4056	1PW041_PW4056
747-400	RB211-524G	747-400	RB211-524G	1RR010_RB211-524G
747-400	RB211-524H2	747-400	RB211-524G	1RR011_RB211-524H
747-400F_FRT	CF6-80C2B1F	747-400F	CF6-80C2B1F	2GE045_CF6-80C2B1F
747-400F_FRT	PW4000-4056	747-400F	PW4056	1PW041_PW4056
747-400F_FRT	RB211-524H2	747-400F	RB211-524H	1RR011_RB211-524H
747-400_CMB	CF6-80C2B1F	747-400	CF6-80C2-B1F	1GE024_CF6-80C2B1F
747-400_CMB	PW4000-4056	747-400	PW4056	1PW041_PW4056
747-SP	JT9D-7A	747SP	JT9D-7A	1PW021_JT9D-7A
747-SP	JT9D-7F	747SP	JT9D-7A	1PW023_JT9D-7F
747-SP	JT9D-7FW	747SP	JT9D-7A	1PW023_JT9D-7F
747-SP	JT9D-7J	747SP	JT9D-7A	1PW021_JT9D-7A
747-SP	RB211-524D4	747SP	RB211-524C2	1RR007_RB211-524D4
747-SR-100B	CF6-45A2	747-100-100SR	CF6-45A2	1GE005_CF6-45A2
757-200	PW2000-2037	757-200	PW2037	PRE113_PW2037
757-200	PW2000-2040	757-200	PW2040	PRE114_PW2040
757-200	RB211-535C	757-200	RB211-535C	1RR012_RB211-535C
757-200	RB211-535E4	757-200	RB211-535E4	3RR028_RB211-535E4
757-200	RB211-535E4B	757-200	RB211-535E4	3RR034_RB211-535E4B
757-200PF_FRT	PW2000-2040	757-200	PW2040	PRE114_PW2040
757-200PF_FRT	RB211-535E4	757-200	RB211-535E4	3RR028_RB211-535E4
767-200	CF6-80A	767-200	CF6-80A	1GE010_CF6-80A

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
767-200	JT9D-7R4D	767-200	JT9D-7R4D	1PW026_JT9D-7R4D-7R4D1
767-200EM	CF6-80A2	767-200	CF6-80A	1GE010_CF6-80A
767-200EM	JT9D-7R4D	767-200	JT9D-7R4D	1PW026_JT9D-7R4D-7R4D1
767-200ER	CF6-80A	767-200ER	CF6-80C2B4F	1GE028_CF6-80C2B4F
767-200ER	CF6-80C2B2	767-200ER	CF6-80C2B4F	1GE025_CF6-80C2B2
767-200ER	CF6-80C2B4	767-200ER	CF6-80C2B4F	1GE027_CF6-80C2B4
767-200ER	CF6-80C2B4F	767-200ER	CF6-80C2B4F	1GE028_CF6-80C2B4F
767-200ER	JT9D-7R4E	767-200	JT9D-7R4D	1PW027_JT9D-7R4E-7R4E1
767-200ER	JT9D-7R4E4	767-200	JT9D-7R4D	1PW028_JT9D-7R4E4-E1
767-200ER	PW4000-4056	767-200ER	PW4056	1PW042_PW4056
767-200ER	PW4000-4060	767-200	CF6-80A	1GE010_CF6-80A
767-200ERM	JT9D-7R4E	767-200	JT9D-7R4D	1PW027_JT9D-7R4E-7R4E1
767-200PC_FRT	CF6-80A	767-200	CF6-80A	1GE010_CF6-80A
767-300	CF6-80C2B2	767-300	CF6-80A2	1GE012_CF6-80A2
767-300	CF6-80C2B2F	767-300	CF6-80A2	1GE012_CF6-80A2
767-300	CF6-80C2B4F	767-300	CF6-80A2	1GE012_CF6-80A2
767-300	JT9D-7R4D	767-300	JT9D-7R4E	1PW027_JT9D-7R4E-7R4E1
767-300	PW4000-4056	767-300	CF6-80A2	1GE012_CF6-80A2
767-300ER	CF6-80C2B2	767-300ER	CF6-80C2B6F	1GE025_CF6-80C2B2
767-300ER	CF6-80C2B4	767-300ER	CF6-80C2B6F	1GE027_CF6-80C2B4
767-300ER	CF6-80C2B4F	767-300ER	CF6-80C2B6F	1GE028_CF6-80C2B4F
767-300ER	CF6-80C2B6	767-300ER	CF6-80C2B6F	1GE029_CF6-80C2B6
767-300ER	CF6-80C2B6F	767-300ER	CF6-80C2B6F	2GE048_CF6-80C2B6F
767-300ER	CF6-80C2B7F	767-300ER	CF6-80C2B6F	2GE055_CF6-80C2B7F
767-300ER	PW4000-4056	767-300ER	PW4060	1PW041_PW4056
767-300ER	PW4000-4060	767-300ER	PW4060	1PW041_PW4056
767-300ER	PW4000-4062	767-300ER	PW4060	1PW041_PW4056
767-300ER	RB211-524H2	767-300ER	RB211-524H	1RR011_RB211-524H
767-300ER	RB211-524H3	767-300ER	RB211-524H	1RR011_RB211-524H

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
767-300ERF_FRT	CF6-80C2B6F	767-300ER	CF6-80C2B6F	1GE030_CF6-80C2B6F
767-300ERF_FRT	CF6-80C2B7F	767-300ER	CF6-80C2B6F	1GE030_CF6-80C2B6F
777-200	PW4000-4074	777-200	PW4084	2PW060_PW4074
777-200	PW4000-4077	777-200	PW4084	2PW061_PW4077
777-200	Trent-875	777-200	TRENT877	2RR025_Trent877
777-200	Trent-877	777-200	TRENT877	2RR025_Trent877
777-200ER	GE90-85B	777-200ER	GE90-85B	3GE064_GE90-85B
777-200ER	GE90-92B	777-200ER	GE90-90B	3GE065_GE90-90B
777-200ER	PW4000-4090	777-200ER	PW4084	2PW062_PW4084
777-200ER	Trent-884	777-200ER	TRENT877	2RR025_Trent877
777-200ER	Trent-892	777-200ER	TRENT877	2RR025_Trent877
777-300	PW4000-4090	777-300	PW4090	PRE118_PW4098
777-300	Trent-892	777-300	TRENT892	2RR027_Trent892
A300-600	CF6-80C2A3	A300-600R	CF6-80C2	1GE018_CF6-80C2A3
A300-600R	CF6-80C2A5	A300-600R	CF6-80C2	1GE020_CF6-80C2A5
A300-600R	CF6-80C2A5F	A300-600R	CF6-80C2	1GE020_CF6-80C2A5
A300-600_FRT	CF6-80C2A5F	A300-600R	CF6-80C2	3GE056_CF6-80C2A5F
A300-620	JT9D-7R4H1	A300-621R-ER	JT9D-7R4H1	1PW030_JT9D-7R4H1
A300-620	PW4000-4158	A300-622R-ER	PW4056	1PW048_PW4158
A300-620R	PW4000-4158	A300-622R-ER	PW4056	1PW048_PW4158
A300-B2-100	CF6-50C	A300-B2-B4	CF6-50C2	1GE007_CF6-50C1-C2
A300-B2-200	CF6-50C2	A300-B2-B4	CF6-50C2	1GE007_CF6-50C1-C2
A300-B2-200	CF6-50C2R	A300-B2-B4	CF6-50C2	1GE008_CF6-50C2R
A300-B2-200FF	CF6-50C2	A300-B2-B4	CF6-50C2	1GE007_CF6-50C1-C2
A300-B4-100	CF6-50C2	A300-B2-B4	CF6-50C2	1GE009_CF6-50E2
A300-B4-100	CF6-50C2R	A300-B2-B4	CF6-50C2	1GE008_CF6-50C2R
A300-B4-120	JT9D-59A	A300-621R-ER	JT9D-7R4H1	1PW033_JT9D-59A
A300-B4-200	CF6-50C2	A300-B2-B4	CF6-50C2	1GE007_CF6-50C1-C2

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
A300-B4-200FF	CF6-50C2	A300-B2-B4	CF6-50C2	1GE007_CF6-50C1-C2
A300-B4-200F_FRT	CF6-50C2	A300-B2-B4	CF6-50C2	1GE007_CF6-50C1-C2
A300-F4-200_FRT	CF6-50C2	A300-B2-B4	CF6-50C2	1GE007_CF6-50C1-C2
A310-200	CF6-80A3	A310-300	CF6-80A3	1GE013_CF6-80A3
A310-200	CF6-80C2A2	A310-300	CF6-80C2A2	1GE016_CF6-80C2A2
A310-220	JT9D-7R4D1	A310-300	JT9D-7R4E1	1PW027_JT9D-7R4E-7R4E1
A310-220	JT9D-7R4E1	A310-300	JT9D-7R4E1	1PW027_JT9D-7R4E-7R4E1
A310-300	CF6-80C2A2	A310-300	CF6-80C2A2	1GE016_CF6-80C2A2
A310-300	CF6-80C2A8	A310-300	CF6-80C2A2	1GE021_CF6-80C2A8
A310-320	JT9D-7R4E1	A310-300	JT9D-7R4E1	1PW027_JT9D-7R4E-7R4E1
A310-320	PW4000-4152	A310-300	CF6-80C2A2	1GE016_CF6-80C2A2
A310-320	PW4000-4156A	A310-300	CF6-80C2A2	1GE016_CF6-80C2A2
A319-110	CFM56-5A4	A319-200	CFM56-5-A1	1CM008_CFM56-5-A1
A319-110	CFM56-5A5	A319-200	CFM56-5-A1	1CM008_CFM56-5-A1
A319-110	CFM56-5B5_P	A319	CFM56-5B3P-25	3CM027_CFM56-5B5/P
A319-110	CFM56-5B6_2P	A319	CFM56-5B3P-25	3CM028_CFM56-5B6/P
A319-110	CFM56-5B6_P	A319	CFM56-5B3P-25	3CM028_CFM56-5B6/P
A319-130	V2500-2522-A5	A319-200	V2522-A5	3IA006_V2522-A5
A319-130	V2500-2524-A5	A319-200	V2522-A5	3IA007_V2524-A5
A320-110	CFM56-5A1	A320-200	CFM56-5-A1	1CM008_CFM56-5-A1
A320-210	CFM56-5A1	A320-200	CFM56-5-A1	1CM008_CFM56-5-A1
A320-210	CFM56-5A3	A320-200	CFM56-5-A1	1CM009_CFM56-5A3
A320-210	CFM56-5B4	A320-200	CFM56-5-A1	1CM008_CFM56-5-A1
A320-210	CFM56-5B4_2	A320-200	CFM56-5-A1	3CM026_CFM56-5B4/P
A320-210	CFM56-5B4_2P	A320-200	CFM56-5B3P-26.5	3CM026_CFM56-5B4/P
A320-210	CFM56-5B4_P	A320-200	CFM56-5B3P-26.5	3CM026_CFM56-5B4/P
A320-230	V2500-2500-A1	A320-200	V2525-A5	1IA001_V2500-A1
A320-230	V2500-2527-A5	A320-200	V2525-A5	1IA003_V2527-A5

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
A321-110	CFM56-5B1_2	A321-100	CFM56-5B1	2CM012_CFM56-5B1
A321-110	CFM56-5B2	A321-100	CFM56-5B1	2CM013_CFM56-5B2
A321-130	V2500-2530-A5	A321-100	V2530-A5	1IA005_V2530-A5
A321-210	CFM56-5B3_2P	A321-200	V2533-A5	3IA008_V2533-A5
A321-210	CFM56-5B3_P	A321-200	V2533-A5	3IA008_V2533-A5
A321-230	V2500-2533-A5	A321-200	V2533-A5	3IA008_V2533-A5
A330-200	CF6-80E1A4	A330-200	CF6-80E1A3	4GE080_CF6-80E1A4
A330-220	PW4000-4168A	A330-200	PW4168	1PW050_PW4168
A330-240	Trent-772B-60	A330-200	TRENT772	2RR023_Trent772
A330-300	CF6-80E1A2	A330-300	CF6-80E1A1	1GE033_CF6-80E1A2
A330-320	PW4000-4164	A330-300	PW4164	1PW049_PW4164
A330-320	PW4000-4168	A330-300	PW4164	1PW049_PW4164
A330-340	Trent-768-60	A330-300	TRENT768	2RR022_Trent768
A330-340	Trent-772-60	A330-300	TRENT768	2RR022_Trent768
A330-340	Trent-772B-60	A330-300	TRENT768	2RR022_Trent768
A340-210	CFM56-5C2	A340-200	CFM56-5C-2	1CM010_CFM56-5C2
A340-210	CFM56-5C2G	A340-200	CFM56-5C-2	1CM010_CFM56-5C2
A340-210	CFM56-5C3_F	A340-200	CFM56-5C-2	1CM010_CFM56-5C2
A340-310	CFM56-5C2	A340-200	CFM56-5C-2	1CM010_CFM56-5C2
A340-310	CFM56-5C3_F	A340-200	CFM56-5C-2	1CM010_CFM56-5C2
A340-310	CFM56-5C4	A340-200	CFM56-5C-2	1CM010_CFM56-5C2
AN4	LGTURB	LGTURB	PW125B	PW125B
AN6	MDTURB	MDTURB	PW120	PW120
ANF	MDTURB	MDTURB	PW120	PW120
AT4	LGTURB	LGTURB	PW125B	PW125B
AT7	LGTURB	LGTURB	PW125B	PW125B
ATP	LGTURB	LGTURB	PW125B	PW125B
ATR	LGTURB	LGTURB	PW125B	PW125B

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
An-124-*_FRT	D-18-T	747-400F	CF6-80C2B1F	1GE024_CF6-80C2B1F
BE1	SMTURB	SMTURB	PT6A	PT6A
BE9	SMTURB	SMTURB	PT6A	PT6A
BEH	SMTURB	SMTURB	PT6A	PT6A
BES	SMTURB	SMTURB	PT6A	PT6A
CD2	SMTURB	SMTURB	PT6A	PT6A
CNC	SMTURB	SMTURB	PT6A	PT6A
CRJ-100ER	CF34-3A1	CRJ	CF34-3A1	1GE035_CF34-3A1
CRJ-100LR	CF34-3A1	CRJ	CF34-3A1	1GE035_CF34-3A1
CRJ-200ER	CF34-3B1	CRJ	CF34-3A1	1GE035_CF34-3A1
CRJ-200LR	CF34-3B1	CRJ	CF34-3A1	1GE035_CF34-3A1
CS5	LGTURB	LGTURB	PW125B	PW125B
CV5	LGTURB	LGTURB	PW125B	PW125B
CVF	LGTURB	LGTURB	PW125B	PW125B
Concorde-100	Olympus-593-610	Concorde	Olympus-593-610	Olympus-593-610
D28	SMTURB	SMTURB	PT6A	PT6A
D38	MDTURB	MDTURB	PW120	PW120
DC-10-10	CF6-6D	DC10-10	CF6-6D	1GE001_CF6-6D
DC-10-10	CF6-6K	DC10-10	CF6-6D	1GE001_CF6-6D
DC-10-10F_FRT	CF6-6D	DC10-10F	CF6-6D	1GE001_CF6-6D
DC-10-15	CF6-50C2F	DC-10-30	CF6-50C2	1GE007_CF6-50C1-C2
DC-10-30	CF6-50C	DC-10-30	CF6-50C2	1GE006_CF6-50C
DC-10-30	CF6-50C1	DC-10-30	CF6-50C2	1GE007_CF6-50C1-C2
DC-10-30	CF6-50C2	DC-10-30	CF6-50C2	1GE007_CF6-50C1-C2
DC-10-30	CF6-50C2R	DC-10-30	CF6-50C2	1GE007_CF6-50C1-C2
DC-10-30CF	CF6-50C2	DC-10-30	CF6-50C2	1GE007_CF6-50C1-C2
DC-10-30F_FRT	CF6-50C2	DC-10-30F	CF6-50C2	1GE007_CF6-50C1-C2
DC-10-30F_FRT	CF6-50C2B	DC-10-30F	CF6-50C2	1GE007_CF6-50C1-C2

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
DC-10-40	JT9D-20	DC10-40	JT9D-20	1PW031_JT9D-20
DC-10-40I	JT9D-59A	DC10-40	JT9D-20	1PW033_JT9D-59A
DC-8-54CF_FRT	JT3D-3B	DC-8-63-63CF	JT3D-7	1PW001_JT3D-3B
DC-8-61C_FRT	JT3D-3B	DC8-55-55CF	JT3D-3B	1PW001_JT3D-3B
DC-8-62CF_FRT	JT3D-3B	DC8-55-55CF	JT3D-3B	1PW001_JT3D-3B
DC-8-62F_FRT	JT3D-3B	DC-8-63-63CF	JT3D-7	1PW002_JT3D-7series
DC-8-63CF_FRT	JT3D-7	DC-8-63-63CF	JT3D-7	1PW002_JT3D-7series
DC-8-63C_FRT	JT3D-7	DC-8-63-63CF	JT3D-7	1PW002_JT3D-7series
DC-8-63_FRT	JT3D-7	DC-8-63-63CF	JT3D-7	1PW002_JT3D-7series
DC-8-71F_FRT	CFM56-2C1	DC-8-71-71CF	CFM56-1B	1CM003_CFM56-2-C5
DC-8-73CF_FRT	CFM56-2C1	DC-8-71-71CF	CFM56-1B	1CM003_CFM56-2-C5
DC-8-73F_FRT	CFM56-2C1	DC-8-71-71CF	CFM56-1B	1CM003_CFM56-2-C5
DC-9-15	JT8D-7	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-15	JT8D-7A	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-15RC	JT8D-7B	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-15RC_FRT	JT8D-7B	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-21	JT8D-11	DC9-31	JT8D-15	1PW009_JT8D-15
DC-9-31	JT8D-7A	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-31	JT8D-7B	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-31	JT8D-9A	DC9-30	JT8D-7	1PW007_JT8D-9series
DC-9-31CF	JT8D-17	DC9-31	JT8D-15	1PW012_JT8D-17
DC-9-32	JT8D-11	DC9-31	JT8D-15	1PW008_JT8D-11
DC-9-32	JT8D-15	DC9-31	JT8D-15	1PW009_JT8D-15
DC-9-32	JT8D-17	DC9-31	JT8D-15	1PW012_JT8D-17
DC-9-32	JT8D-7	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-32	JT8D-7A	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-32	JT8D-7B	DC9-30	JT8D-7	1PW004_JT8D-7series
DC-9-32	JT8D-9	DC9-30	JT8D-7	1PW006_JT8D-9series

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
DC-9-32	JT8D-9A	DC9-30	JT8D-7	1PW006_JT8D-9series
DC-9-33CF	JT8D-9A	DC9-30	JT8D-7	1PW006_JT8D-9series
DC-9-41	JT8D-11	DC9-50	JT8D-15	1PW008_JT8D-11
DC-9-41	JT8D-15	DC9-50	JT8D-15	1PW009_JT8D-15
DC-9-41_FRT	JT8D-11	DC9-50	JT8D-15	1PW008_JT8D-11
DC-9-51	JT8D-17	DC9-50	JT8D-15	1PW012_JT8D-17
DC-9-51	JT8D-17A	DC9-50	JT8D-15	1PW014_JT8D-17A
DFL	Blank-Blank	CRJ	CF34-3A1	1GE034_CF34-3A
DH1	MDTURB	MDTURB	PW120	PW120
DH3	MDTURB	MDTURB	PW120	PW120
DH7	LGTURB	LGTURB	PW125B	PW125B
DH8	MDTURB	MDTURB	PW120	PW120
DHT	SMTURB	SMTURB	PT6A	PT6A
EM2	SMTURB	SMTURB	PT6A	PT6A
EM3	Blank-Blank	CRJ	CF34-3A1	1GE035_CF34-3A1
EMB	SMTURB	SMTURB	PT6A	PT6A
EMJ	Blank-Blank	CRJ	CF34-3A1	1GE035_CF34-3A1
ER3	Blank-Blank	CRJ	CF34-3A1	1GE035_CF34-3A1
ER4	Blank-Blank	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ	Blank-Blank	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ-145-EP	AE-A	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ-145-EP	AE-A1_1	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ-145-ER	AE-A	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ-145-EU	AE-A	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ-145-LR	AE-A1	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ-145-LU	AE-A1	CRJ	CF34-3A1	1GE035_CF34-3A1
ERJ-145-MP	AE-A1	CRJ	CF34-3A1	1GE035_CF34-3A1
F.28-1000	Spey-555-15	F-28-4000	MK555-15H	1RR017_SPEYMk555

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
F.28-2000	Spey-555-15	F-28-4000	MK555-15H	1RR017_SPEYMk555
F.28-3000	Spey-555-15H	F-28-4000	MK555-15H	1RR017_SPEYMk555
F.28-4000	Spey-555-15H	F-28-4000	MK555-15H	1RR017_SPEYMk555
F.28-4000	Spey-555-15P	F-28-4000	MK555-15H	1RR017_SPEYMk555
F27	LGTURB	LGTURB	PW125B	PW125B
F50	LGTURB	LGTURB	PW125B	PW125B
FRJ	Blank-Blank	CRJ	CF34-3A1	1GE035_CF34-3A1
HS7	LGTURB	LGTURB	PW125B	PW125B
IL8	LGTURB	LGTURB	PW125B	PW125B
Il-62-*	NK-8-4	DC-8-63-63CF	JT3D-7	1PW004_JT8D-7series
Il-62-M	D-30-KU	DC-8-63-63CF	JT3D-7	1PW004_JT8D-7series
Il-76-M_FRT	D-30-KP-2	DC-8-63-63CF	JT3D-7	1PW004_JT8D-7series
Il-76-T_FRT	D-30-KP-2	DC-8-63-63CF	JT3D-7	1PW004_JT8D-7series
Il-86-*	NK-86	L-1011-1-100	RB211-22B	1RR002_RB211-22B
Il-86-*	NK-86-Blank	L-1011-1-100	RB211-22B	1RR002_RB211-22B
Il-96-300	PS-90-A	L-1011-1-100	RB211-22B	1RR003_RB211-22B
J31	SMTURB	SMTURB	PT6A	PT6A
J41	MDTURB	MDTURB	PW120	PW120
L-1011-1	RB211-22B	L-1011-1-100	RB211-22B	1RR003_RB211-22B
L-1011-150	RB211-22B	L-1011-1-100	RB211-22B	1RR003_RB211-22B
L-1011-200_FRT	RB211-524B	L-1011-1-100F	RB211-22B	1RR003_RB211-22B
L-1011-200_FRT	RB211-524B4	L-1011-1-100F	RB211-22B	1RR003_RB211-22B
L-1011-50	RB211-22B	L-1011-1-100	RB211-22B	1RR003_RB211-22B
L-1011-500	RB211-524B4	L1011-500AC	RB211-524B4	1RR004_RB211-524Bseries
L11	Blank-Blank	L-1011-1-100	RB211-22B	1RR003_RB211-22B
L4T	SMTURB	SMTURB	PT6A	PT6A
LOE	LGTURB	LGTURB	PW125B	PW125B
LOF	LGTURB	LGTURB	PW125B	PW125B

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
LOH	LGTURB	LGTURB	PW125B	PW125B
LOM	LGTURB	LGTURB	PW125B	PW125B
LRJ	Blank-Blank	CRJ	CF34-3A1	1GE034_CF34-3A
MD-11-CF_QC	PW4000-4460	MD-11ER	PW4460	1PW052_PW4460
MD-11-CF_QC	PW4000-4462	MD-11ER	PW4460	1PW052_PW4460
MD-11-Combi_CMB	CF6-80C2D1F	MD-11	CF6-80C2D1F	2GE049_CF6-80C2D1F
MD-11-Freighter_FRT	CF6-80C2D1F	MD-11F	CF6-80C2D1F	2GE049_CF6-80C2D1F
MD-11-Freighter_FRT	PW4000-4460	MD-11F	PW4460	1PW057_PW4x60
MD-11-Passenger	CF6-80C2D1F	MD-11	CF6-80C2D1F	2GE049_CF6-80C2D1F
MD-11-Passenger	PW4000-4460	MD-11ER	PW4460	1PW052_PW4460
MD-11-Passenger	PW4000-4462	MD-11ER	PW4460	1PW058_PW4x62
MD-80-81	JT8D-217	MD-82	JT8D-217A	1PW018_JT8D-217series
MD-80-81	JT8D-217C	MD-82	JT8D-217A	1PW018_JT8D-217series
MD-80-82	JT8D-217	MD-82	JT8D-217A	1PW018_JT8D-217series
MD-80-82	JT8D-217A	MD-82	JT8D-217A	1PW018_JT8D-217series
MD-80-82	JT8D-217C	MD-82	JT8D-217A	1PW018_JT8D-217series
MD-80-82	JT8D-219	MD-83	JT8D-219	1PW019_JT8D-219
MD-80-83	JT8D-217C	MD-83	JT8D-219	1PW018_JT8D-217series
MD-80-83	JT8D-219	MD-83	JT8D-219	1PW019_JT8D-219
MD-80-87	JT8D-217C	MD-87	JT8D-217C	1PW018_JT8D-217series
MD-80-87	JT8D-219	MD-87	JT8D-217C	1PW019_JT8D-219
MD-80-88	JT8D-219	MD-83	JT8D-219	1PW019_JT8D-219
MD-90-30	V2500-2525-D5	MD90-30	V2525-D5	1IA002_V2525-D5
MD-90-30	V2500-2528-D5	MD90-30	V2525-D5	1IA002_V2525-D5
MU2	SMTURB	SMTURB	PT6A	PT6A
ND2	MDTURB	MDTURB	PW120	PW120
One-Eleven-200	Spey-506-14A	BAC111-500	MK512-14	1RR016_SPEYMk511
One-Eleven-500	Spey-512-14DW	BAC111-500	MK512-14	1RR015_SPEYMk511

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
One-Eleven-560	Spey-512-14DW	BAC111-500	MK512-14	1RR015_SPEYMk511
PL2	SMTURB	SMTURB	PT6A	PT6A
PL6	SMTURB	SMTURB	PT6A	PT6A
RJ-RJ100	LF507-1F	RJ-100	LF507	1TL004_LF507-1F-1H
RJ-RJ70	LF507-1F	RJ-85	LF507	1TL004_LF507-1F-1H
RJ-RJ85	LF507-1F	RJ-85	LF507	1TL004_LF507-1F-1H
S20	LGTURB	LGTURB	PW125B	PW125B
SF3	MDTURB	MDTURB	PW120	PW120
SH3	MDTURB	MDTURB	PW120	PW120
SH6	MDTURB	MDTURB	PW120	PW120
SHS	SMTURB	SMTURB	PT6A	PT6A
SWM	SMTURB	SMTURB	PT6A	PT6A
T20	Blank-Blank	757-200	RB211-535E4	3RR028_RB211-535E4
Tu-134-A	D-30-2	DC9-30	JT8D-7	1PW004_JT8D-7series
Tu-134-A	D-30-3	DC9-30	JT8D-7	1PW004_JT8D-7series
Tu-134-B	D-30-3	DC9-30	JT8D-7	1PW004_JT8D-7series
Tu-154-B	NK-8-2U	727-200	JT8D-15-15A	1PW009_JT8D-15
Tu-154-M	D-30-KU-154-II	727-200	JT8D-15-15A	1PW009_JT8D-15
Tu-204-100C_FRT	PS-90-AT	757-200	RB211-535C	1RR012_RB211-535C
YN2	SMTURB	SMTURB	PT6A	PT6A
YN7	LGTURB	LGTURB	PW125B	PW125B
YS1	LGTURB	LGTURB	PW125B	PW125B

Appendix B – Airplane/Engine Substitution Tables for 1999 Emissions Inventory Calculations

Schedule Airplane	Schedule Engine	Performance Airplane	Performance Engine	Emissions Engine
Yak-40-*	AI-25	727-100	JT8D-7	1PW002_JT3D-7series
Yak-40-*	AI-25-Blank	727-100	JT8D-7	1PW002_JT3D-7series
Yak-42-*	D-36	727-100	JT8D-7	1PW002_JT3D-7series
Yak-42-*	D-36-Blank	727-100	JT8D-7	1PW002_JT3D-7series
Yak-42-D	D-36	727-100	JT8D-7	1PW002_JT3D-7series
Yak-42-D	D-36-Blank	727-100	JT8D-7	1PW002_JT3D-7series

Notes:
SMTURB = Small Turboprop
MDTURB = Medium Turboprop
LGTURB = Large Turboprop

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-1. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in January 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.35E+07	9.80%	4.05E+05	9.02%	1.83E+05	34.52%	6.15E+05	32.93%	12.09	5.46	18.35
1 - 2	9.13E+06	12.48%	1.47E+05	12.29%	2.96E+04	40.10%	1.04E+05	38.50%	16.11	3.24	11.40
2 - 3	8.53E+06	14.98%	1.45E+05	15.51%	2.43E+04	44.69%	8.75E+04	43.19%	16.93	2.85	10.25
3 - 4	9.86E+06	17.86%	1.79E+05	19.49%	2.30E+04	49.03%	7.98E+04	47.47%	18.14	2.33	8.09
4 - 5	9.07E+06	20.52%	1.53E+05	22.89%	2.38E+04	53.52%	7.98E+04	51.74%	16.83	2.62	8.79
5 - 6	8.94E+06	23.14%	1.44E+05	26.09%	2.40E+04	58.05%	7.96E+04	56.01%	16.06	2.69	8.91
6 - 7	8.90E+06	25.74%	1.41E+05	29.23%	2.33E+04	62.45%	7.41E+04	59.98%	15.90	2.62	8.33
7 - 8	9.60E+06	28.55%	1.44E+05	32.45%	2.42E+04	67.01%	8.06E+04	64.29%	15.04	2.52	8.39
8 - 9	9.16E+06	31.24%	1.31E+05	35.37%	2.24E+04	71.23%	7.53E+04	68.33%	14.35	2.44	8.23
9 - 10	1.91E+07	36.82%	2.65E+05	41.28%	2.51E+04	75.96%	8.31E+04	72.78%	13.91	1.31	4.36
10 - 11	1.06E+08	67.74%	1.25E+06	69.00%	7.33E+04	89.79%	3.18E+05	89.82%	11.79	0.69	3.01
11 - 12	1.09E+08	99.61%	1.37E+06	99.57%	5.33E+04	99.84%	1.86E+05	99.79%	12.61	0.49	1.71
12 - 13	8.01E+05	99.84%	1.12E+04	99.81%	5.82E+02	99.95%	2.11E+03	99.90%	13.94	0.73	2.64
13 - 14	2.69E+05	99.92%	3.62E+03	99.89%	2.16E+02	99.99%	9.11E+02	99.95%	13.46	0.80	3.39
14 - 15	1.07E+04	99.93%	1.92E+02	99.90%	2.10E+00	99.99%	3.74E+01	99.95%	18.00	0.20	3.50
15 - 16	1.07E+04	99.93%	1.92E+02	99.90%	2.10E+00	99.99%	3.74E+01	99.95%	18.00	0.20	3.50
16 - 17	8.94E+04	99.96%	1.61E+03	99.94%	1.79E+01	99.99%	3.13E+02	99.97%	18.00	0.20	3.50
17 - 18	1.19E+05	99.99%	2.14E+03	99.99%	2.38E+01	100.00%	4.16E+02	99.99%	18.00	0.20	3.50
18 - 19	3.42E+04	100.00%	6.16E+02	100.00%	6.80E+00	100.00%	1.20E+02	100.00%	18.00	0.20	3.50
Global Total	3.42E+08		4.49E+06		5.30E+05		1.87E+06		13.15	1.55	5.46

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-2. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in February 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.35E+07	9.85%	4.06E+05	9.06%	1.82E+05	34.78%	6.15E+05	33.03%	12.11	5.44	18.35
1 - 2	9.16E+06	12.54%	1.48E+05	12.36%	2.94E+04	40.40%	1.04E+05	38.61%	16.14	3.21	11.34
2 - 3	8.54E+06	15.05%	1.45E+05	15.60%	2.41E+04	44.99%	8.71E+04	43.29%	17.02	2.81	10.19
3 - 4	9.87E+06	17.95%	1.79E+05	19.61%	2.27E+04	49.32%	7.94E+04	47.56%	18.18	2.30	8.05
4 - 5	9.12E+06	20.63%	1.54E+05	23.03%	2.36E+04	53.82%	7.97E+04	51.84%	16.85	2.58	8.74
5 - 6	8.88E+06	23.24%	1.43E+05	26.23%	2.37E+04	58.35%	7.94E+04	56.10%	16.13	2.67	8.94
6 - 7	8.97E+06	25.87%	1.43E+05	29.41%	2.30E+04	62.74%	7.43E+04	60.10%	15.90	2.57	8.29
7 - 8	9.60E+06	28.69%	1.45E+05	32.64%	2.39E+04	67.30%	8.05E+04	64.42%	15.08	2.49	8.39
8 - 9	9.30E+06	31.42%	1.33E+05	35.62%	2.21E+04	71.51%	7.55E+04	68.48%	14.34	2.37	8.12
9 - 10	1.92E+07	37.07%	2.68E+05	41.59%	2.46E+04	76.20%	8.31E+04	72.94%	13.92	1.28	4.32
10 - 11	1.04E+08	67.62%	1.23E+06	69.00%	7.17E+04	89.88%	3.12E+05	89.73%	11.81	0.69	3.01
11 - 12	1.09E+08	99.60%	1.37E+06	99.55%	5.21E+04	99.83%	1.87E+05	99.78%	12.57	0.48	1.72
12 - 13	8.64E+05	99.85%	1.21E+04	99.82%	6.10E+02	99.95%	2.29E+03	99.90%	13.98	0.71	2.65
13 - 14	2.18E+05	99.92%	2.96E+03	99.89%	2.03E+02	99.99%	9.05E+02	99.95%	13.55	0.93	4.15
14 - 15	1.24E+04	99.92%	2.24E+02	99.89%	2.50E+00	99.99%	4.35E+01	99.95%	18.00	0.20	3.50
15 - 16	1.24E+04	99.93%	2.24E+02	99.90%	2.50E+00	99.99%	4.35E+01	99.95%	18.00	0.20	3.50
16 - 17	9.40E+04	99.95%	1.69E+03	99.94%	1.88E+01	99.99%	3.29E+02	99.97%	18.00	0.20	3.50
17 - 18	1.24E+05	99.99%	2.24E+03	99.99%	2.48E+01	100.00%	4.35E+02	99.99%	18.00	0.20	3.50
18 - 19	3.58E+04	100.00%	6.44E+02	100.00%	7.20E+00	100.00%	1.25E+02	100.00%	18.00	0.20	3.50
GlobalTotal	3.40E+08		4.48E+06		5.24E+05		1.86E+06		13.16	1.54	5.47

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-3. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in March 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.38E+07	9.84%	4.09E+05	9.06%	1.82E+05	34.95%	6.18E+05	33.18%	12.12	5.39	18.32
1 - 2	9.23E+06	12.53%	1.49E+05	12.36%	2.93E+04	40.58%	1.05E+05	38.79%	16.14	3.17	11.33
2 - 3	8.61E+06	15.04%	1.47E+05	15.60%	2.38E+04	45.15%	8.76E+04	43.49%	17.03	2.77	10.18
3 - 4	9.95E+06	17.94%	1.81E+05	19.61%	2.25E+04	49.47%	8.00E+04	47.78%	18.19	2.26	8.05
4 - 5	9.19E+06	20.62%	1.55E+05	23.04%	2.33E+04	53.96%	8.03E+04	52.09%	16.86	2.54	8.73
5 - 6	8.93E+06	23.23%	1.44E+05	26.24%	2.35E+04	58.47%	7.98E+04	56.37%	16.14	2.63	8.93
6 - 7	9.05E+06	25.87%	1.44E+05	29.42%	2.29E+04	62.88%	7.48E+04	60.38%	15.90	2.54	8.27
7 - 8	9.66E+06	28.68%	1.46E+05	32.65%	2.39E+04	67.47%	8.11E+04	64.73%	15.09	2.47	8.39
8 - 9	9.30E+06	31.40%	1.34E+05	35.61%	2.20E+04	71.70%	7.58E+04	68.80%	14.36	2.37	8.15
9 - 10	1.94E+07	37.07%	2.71E+05	41.61%	2.45E+04	76.41%	8.37E+04	73.29%	13.92	1.26	4.30
10 - 11	1.05E+08	67.62%	1.24E+06	69.05%	7.12E+04	90.08%	3.12E+05	90.03%	11.83	0.68	2.98
11 - 12	1.10E+08	99.65%	1.38E+06	99.61%	5.08E+04	99.84%	1.82E+05	99.80%	12.56	0.46	1.66
12 - 13	7.33E+05	99.86%	1.01E+04	99.83%	5.61E+02	99.95%	1.92E+03	99.90%	13.74	0.76	2.62
13 - 14	2.12E+05	99.92%	2.87E+03	99.89%	2.00E+02	99.99%	8.59E+02	99.95%	13.50	0.94	4.05
14 - 15	1.07E+04	99.93%	1.92E+02	99.90%	2.10E+00	99.99%	3.74E+01	99.95%	18.00	0.20	3.50
15 - 16	1.07E+04	99.93%	1.92E+02	99.90%	2.10E+00	99.99%	3.74E+01	99.95%	18.00	0.20	3.50
16 - 17	8.94E+04	99.96%	1.61E+03	99.94%	1.79E+01	99.99%	3.13E+02	99.97%	18.00	0.20	3.50
17 - 18	1.19E+05	99.99%	2.14E+03	99.99%	2.38E+01	100.00%	4.16E+02	99.99%	18.00	0.20	3.50
18 - 19	3.42E+04	100.00%	6.16E+02	100.00%	6.80E+00	100.00%	1.20E+02	100.00%	18.00	0.20	3.50
Global Total	3.43E+08		4.52E+06		5.20E+05		1.86E+06		13.17	1.52	5.43

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-4. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in April 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.37E+07	9.76%	4.08E+05	8.99%	1.77E+05	34.62%	6.12E+05	33.07%	12.11	5.27	18.17
1 - 2	9.17E+06	12.42%	1.48E+05	12.25%	2.86E+04	40.20%	1.03E+05	38.65%	16.16	3.12	11.25
2 - 3	8.55E+06	14.90%	1.45E+05	15.46%	2.34E+04	44.77%	8.67E+04	43.34%	17.00	2.74	10.14
3 - 4	9.88E+06	17.77%	1.80E+05	19.42%	2.20E+04	49.08%	7.90E+04	47.61%	18.18	2.23	8.00
4 - 5	9.13E+06	20.41%	1.54E+05	22.80%	2.30E+04	53.56%	7.95E+04	51.92%	16.84	2.52	8.71
5 - 6	8.89E+06	22.99%	1.43E+05	25.96%	2.31E+04	58.07%	7.92E+04	56.20%	16.11	2.60	8.90
6 - 7	8.97E+06	25.60%	1.43E+05	29.11%	2.26E+04	62.49%	7.42E+04	60.21%	15.89	2.52	8.26
7 - 8	9.65E+06	28.39%	1.45E+05	32.31%	2.35E+04	67.08%	8.05E+04	64.56%	15.05	2.44	8.35
8 - 9	9.21E+06	31.07%	1.32E+05	35.22%	2.17E+04	71.32%	7.51E+04	68.62%	14.36	2.36	8.15
9 - 10	1.92E+07	36.64%	2.68E+05	41.12%	2.42E+04	76.05%	8.30E+04	73.11%	13.93	1.26	4.32
10 - 11	1.06E+08	67.41%	1.26E+06	68.82%	7.12E+04	89.95%	3.11E+05	89.92%	11.85	0.67	2.93
11 - 12	1.11E+08	99.66%	1.40E+06	99.62%	5.07E+04	99.85%	1.83E+05	99.80%	12.57	0.46	1.64
12 - 13	6.84E+05	99.86%	9.42E+03	99.83%	5.40E+02	99.95%	1.88E+03	99.90%	13.76	0.79	2.75
13 - 14	2.09E+05	99.92%	2.83E+03	99.89%	1.90E+02	99.99%	8.25E+02	99.95%	13.52	0.91	3.94
14 - 15	1.11E+04	99.92%	2.00E+02	99.89%	2.20E+00	99.99%	3.90E+01	99.95%	18.00	0.20	3.50
15 - 16	1.11E+04	99.93%	2.00E+02	99.90%	2.20E+00	99.99%	3.90E+01	99.95%	18.00	0.20	3.50
16 - 17	9.34E+04	99.95%	1.68E+03	99.94%	1.87E+01	99.99%	3.27E+02	99.97%	18.00	0.20	3.50
17 - 18	1.24E+05	99.99%	2.24E+03	99.99%	2.49E+01	100.00%	4.36E+02	99.99%	18.00	0.20	3.50
18 - 19	3.59E+04	100.00%	6.45E+02	100.00%	7.20E+00	100.00%	1.26E+02	100.00%	18.00	0.20	3.50
Global Total	3.45E+08		4.54E+06		5.12E+05		1.85E+06		13.16	1.49	5.36

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-5. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in May 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.41E+07	9.82%	4.14E+05	9.05%	1.80E+05	35.00%	6.20E+05	33.22%	12.14	5.27	18.16
1 - 2	9.28E+06	12.49%	1.50E+05	12.33%	2.91E+04	40.68%	1.04E+05	38.82%	16.18	3.14	11.26
2 - 3	8.64E+06	14.98%	1.47E+05	15.55%	2.35E+04	45.25%	8.74E+04	43.50%	17.05	2.72	10.12
3 - 4	9.99E+06	17.85%	1.82E+05	19.52%	2.21E+04	49.56%	7.98E+04	47.78%	18.20	2.22	7.99
4 - 5	9.24E+06	20.51%	1.56E+05	22.93%	2.30E+04	54.04%	8.03E+04	52.09%	16.89	2.49	8.69
5 - 6	9.10E+06	23.13%	1.47E+05	26.13%	2.32E+04	58.56%	8.04E+04	56.40%	16.11	2.55	8.84
6 - 7	9.15E+06	25.76%	1.45E+05	29.31%	2.26E+04	62.97%	7.52E+04	60.43%	15.90	2.47	8.22
7 - 8	9.88E+06	28.60%	1.49E+05	32.56%	2.35E+04	67.54%	8.16E+04	64.81%	15.04	2.38	8.26
8 - 9	9.47E+06	31.33%	1.36E+05	35.53%	2.18E+04	71.79%	7.63E+04	68.90%	14.36	2.31	8.05
9 - 10	1.90E+07	36.79%	2.62E+05	41.27%	2.39E+04	76.45%	8.29E+04	73.34%	13.84	1.26	4.37
10 - 11	1.06E+08	67.26%	1.26E+06	68.77%	7.00E+04	90.07%	3.11E+05	90.00%	11.88	0.66	2.93
11 - 12	1.13E+08	99.70%	1.41E+06	99.66%	5.03E+04	99.86%	1.83E+05	99.81%	12.54	0.45	1.62
12 - 13	6.27E+05	99.88%	8.66E+03	99.85%	5.08E+02	99.96%	1.92E+03	99.91%	13.81	0.81	3.06
13 - 14	1.45E+05	99.92%	2.01E+03	99.90%	1.53E+02	99.99%	7.84E+02	99.95%	13.88	1.06	5.42
14 - 15	9.38E+03	99.93%	1.69E+02	99.90%	1.90E+00	99.99%	3.28E+01	99.95%	18.00	0.20	3.50
15 - 16	9.38E+03	99.93%	1.69E+02	99.90%	1.90E+00	99.99%	3.28E+01	99.95%	18.00	0.20	3.50
16 - 17	8.88E+04	99.96%	1.60E+03	99.94%	1.78E+01	99.99%	3.11E+02	99.97%	18.00	0.20	3.50
17 - 18	1.19E+05	99.99%	2.14E+03	99.99%	2.38E+01	100.00%	4.17E+02	99.99%	18.00	0.20	3.50
18 - 19	3.43E+04	100.00%	6.17E+02	100.00%	6.90E+00	100.00%	1.20E+02	100.00%	18.00	0.20	3.50
Global Total	3.47E+08		4.58E+06		5.14E+05		1.87E+06		13.17	1.48	5.37

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-6. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in June 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.47E+07	9.72%	4.21E+05	8.95%	1.83E+05	34.89%	6.29E+05	33.09%	12.14	5.27	18.15
1 - 2	9.43E+06	12.36%	1.53E+05	12.20%	2.96E+04	40.54%	1.06E+05	38.67%	16.20	3.13	11.25
2 - 3	8.78E+06	14.82%	1.50E+05	15.39%	2.39E+04	45.10%	8.89E+04	43.34%	17.05	2.72	10.13
3 - 4	1.02E+07	17.66%	1.85E+05	19.32%	2.26E+04	49.41%	8.12E+04	47.61%	18.21	2.22	7.99
4 - 5	9.39E+06	20.29%	1.59E+05	22.69%	2.34E+04	53.88%	8.17E+04	51.90%	16.90	2.50	8.70
5 - 6	9.24E+06	22.88%	1.49E+05	25.86%	2.36E+04	58.38%	8.17E+04	56.20%	16.13	2.55	8.84
6 - 7	9.29E+06	25.48%	1.48E+05	29.01%	2.30E+04	62.77%	7.64E+04	60.21%	15.92	2.47	8.22
7 - 8	1.00E+07	28.30%	1.51E+05	32.22%	2.39E+04	67.33%	8.28E+04	64.56%	15.06	2.38	8.25
8 - 9	9.64E+06	31.00%	1.39E+05	35.17%	2.22E+04	71.57%	7.75E+04	68.64%	14.39	2.30	8.04
9 - 10	1.93E+07	36.42%	2.68E+05	40.87%	2.46E+04	76.26%	8.46E+04	73.09%	13.85	1.27	4.37
10 - 11	1.09E+08	67.03%	1.30E+06	68.52%	7.18E+04	89.96%	3.18E+05	89.82%	11.90	0.66	2.91
11 - 12	1.17E+08	99.70%	1.46E+06	99.66%	5.18E+04	99.86%	1.90E+05	99.81%	12.56	0.44	1.63
12 - 13	6.65E+05	99.88%	9.14E+03	99.85%	5.19E+02	99.96%	1.94E+03	99.91%	13.75	0.78	2.92
13 - 14	1.58E+05	99.93%	2.21E+03	99.90%	1.54E+02	99.99%	8.16E+02	99.95%	13.97	0.97	5.15
14 - 15	9.38E+03	99.93%	1.69E+02	99.90%	1.90E+00	99.99%	3.28E+01	99.95%	18.00	0.20	3.50
15 - 16	9.38E+03	99.93%	1.69E+02	99.91%	1.90E+00	99.99%	3.28E+01	99.96%	18.00	0.20	3.50
16 - 17	8.88E+04	99.96%	1.60E+03	99.94%	1.78E+01	99.99%	3.11E+02	99.97%	18.00	0.20	3.50
17 - 18	1.19E+05	99.99%	2.14E+03	99.99%	2.38E+01	100.00%	4.17E+02	99.99%	18.00	0.20	3.50
18 - 19											
Global Total	3.57E+08		4.70E+06		5.24E+05		1.90E+06		13.17	1.47	5.33

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-7. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in July 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.48E+07	9.63%	4.23E+05	8.91%	1.85E+05	35.00%	6.34E+05	33.01%	12.16	5.32	18.22
1 - 2	9.45E+06	12.25%	1.53E+05	12.13%	3.00E+04	40.68%	1.07E+05	38.58%	16.20	3.17	11.30
2 - 3	8.80E+06	14.69%	1.50E+05	15.29%	2.42E+04	45.27%	8.94E+04	43.24%	17.06	2.75	10.17
3 - 4	1.02E+07	17.51%	1.85E+05	19.20%	2.28E+04	49.58%	8.17E+04	47.49%	18.21	2.24	8.02
4 - 5	9.40E+06	20.11%	1.59E+05	22.55%	2.36E+04	54.06%	8.21E+04	51.77%	16.92	2.52	8.74
5 - 6	9.25E+06	22.67%	1.49E+05	25.69%	2.38E+04	58.56%	8.22E+04	56.06%	16.13	2.57	8.88
6 - 7	9.29E+06	25.24%	1.48E+05	28.81%	2.32E+04	62.95%	7.68E+04	60.05%	15.94	2.49	8.27
7 - 8	1.00E+07	28.02%	1.51E+05	32.00%	2.40E+04	67.50%	8.32E+04	64.39%	15.07	2.40	8.29
8 - 9	9.66E+06	30.70%	1.39E+05	34.93%	2.24E+04	71.75%	7.79E+04	68.45%	14.40	2.32	8.07
9 - 10	1.94E+07	36.08%	2.69E+05	40.59%	2.48E+04	76.45%	8.57E+04	72.92%	13.84	1.28	4.41
10 - 11	1.11E+08	66.82%	1.32E+06	68.34%	7.20E+04	90.08%	3.23E+05	89.77%	11.87	0.65	2.91
11 - 12	1.19E+08	99.69%	1.49E+06	99.65%	5.16E+04	99.86%	1.93E+05	99.81%	12.52	0.44	1.62
12 - 13	6.77E+05	99.88%	9.30E+03	99.85%	5.26E+02	99.96%	1.95E+03	99.91%	13.74	0.78	2.88
13 - 14	1.78E+05	99.93%	2.47E+03	99.90%	1.60E+02	99.99%	8.16E+02	99.95%	13.88	0.90	4.59
14 - 15	9.38E+03	99.93%	1.69E+02	99.90%	1.90E+00	99.99%	3.28E+01	99.95%	18.00	0.20	3.50
15 - 16	9.38E+03	99.93%	1.69E+02	99.91%	1.90E+00	99.99%	3.28E+01	99.96%	18.00	0.20	3.50
16 - 17	8.88E+04	99.96%	1.60E+03	99.94%	1.78E+01	99.99%	3.11E+02	99.97%	18.00	0.20	3.50
17 - 18	1.19E+05	99.99%	2.14E+03	99.99%	2.38E+01	100.00%	4.17E+02	99.99%	18.00	0.20	3.50
18 - 19	3.43E+04	100.00%	6.17E+02	100.00%	6.90E+00	100.00%	1.20E+02	100.00%	18.00	0.20	3.50
Global Total	3.61E+08		4.75E+06		5.28E+05		1.92E+06		13.15	1.46	5.32

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-8. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in August 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.53E+07	9.70%	4.31E+05	8.98%	1.90E+05	35.48%	6.46E+05	33.23%	12.19	5.38	18.28
1 - 2	9.60E+06	12.33%	1.56E+05	12.22%	3.01E+04	41.10%	1.08E+05	38.78%	16.22	3.14	11.24
2 - 3	8.93E+06	14.78%	1.53E+05	15.41%	2.45E+04	45.68%	9.06E+04	43.45%	17.10	2.74	10.14
3 - 4	1.04E+07	17.63%	1.89E+05	19.34%	2.31E+04	49.99%	8.29E+04	47.71%	18.23	2.23	8.00
4 - 5	9.59E+06	20.26%	1.62E+05	22.73%	2.39E+04	54.44%	8.33E+04	52.00%	16.92	2.49	8.68
5 - 6	9.34E+06	22.82%	1.51E+05	25.88%	2.39E+04	58.91%	8.28E+04	56.26%	16.19	2.56	8.87
6 - 7	9.43E+06	25.41%	1.50E+05	29.01%	2.34E+04	63.28%	7.78E+04	60.27%	15.95	2.48	8.25
7 - 8	1.02E+07	28.20%	1.54E+05	32.22%	2.44E+04	67.83%	8.44E+04	64.61%	15.10	2.40	8.29
8 - 9	9.78E+06	30.89%	1.41E+05	35.16%	2.26E+04	72.05%	7.88E+04	68.67%	14.45	2.31	8.06
9 - 10	1.96E+07	36.27%	2.71E+05	40.82%	2.47E+04	76.67%	8.63E+04	73.11%	13.83	1.26	4.40
10 - 11	1.10E+08	66.55%	1.31E+06	68.15%	7.20E+04	90.11%	3.22E+05	89.70%	11.88	0.65	2.92
11 - 12	1.21E+08	99.73%	1.51E+06	99.70%	5.23E+04	99.87%	1.97E+05	99.82%	12.52	0.43	1.63
12 - 13	6.29E+05	99.90%	8.75E+03	99.88%	4.94E+02	99.96%	1.91E+03	99.92%	13.91	0.78	3.04
13 - 14	1.86E+05	99.95%	2.59E+03	99.93%	1.84E+02	99.99%	8.82E+02	99.97%	13.95	0.99	4.75
14 - 15	6.32E+03	99.95%	1.14E+02	99.94%	1.30E+00	99.99%	2.21E+01	99.97%	18.00	0.20	3.50
15 - 16	6.32E+03	99.96%	1.14E+02	99.94%	1.30E+00	99.99%	2.21E+01	99.97%	18.00	0.20	3.50
16 - 17	6.05E+04	99.97%	1.09E+03	99.96%	1.21E+01	100.00%	2.12E+02	99.98%	18.00	0.20	3.50
17 - 18	7.96E+04	99.99%	1.43E+03	99.99%	1.59E+01	100.00%	2.79E+02	100.00%	18.00	0.20	3.50
18 - 19	2.29E+04	100.00%	4.13E+02	100.00%	4.60E+00	100.00%	8.03E+01	100.00%	18.00	0.20	3.50
Global Total	3.64E+08		4.80E+06		5.36E+05		1.94E+06		13.17	1.47	5.33

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-9. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in September 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.49E+07	9.76%	4.23E+05	9.01%	1.86E+05	35.55%	6.35E+05	33.26%	12.15	5.34	18.20
1 - 2	9.45E+06	12.41%	1.53E+05	12.27%	2.94E+04	41.18%	1.06E+05	38.81%	16.18	3.11	11.21
2 - 3	8.81E+06	14.88%	1.50E+05	15.46%	2.39E+04	45.75%	8.92E+04	43.49%	17.01	2.72	10.13
3 - 4	1.02E+07	17.74%	1.85E+05	19.40%	2.26E+04	50.06%	8.16E+04	47.76%	18.15	2.21	7.99
4 - 5	9.48E+06	20.39%	1.60E+05	22.81%	2.33E+04	54.52%	8.20E+04	52.06%	16.86	2.46	8.65
5 - 6	9.26E+06	22.98%	1.49E+05	25.98%	2.34E+04	58.98%	8.17E+04	56.35%	16.12	2.52	8.83
6 - 7	9.33E+06	25.60%	1.48E+05	29.14%	2.29E+04	63.36%	7.68E+04	60.37%	15.89	2.46	8.23
7 - 8	1.01E+07	28.41%	1.51E+05	32.36%	2.38E+04	67.91%	8.31E+04	64.73%	15.04	2.36	8.26
8 - 9	9.67E+06	31.12%	1.39E+05	35.32%	2.21E+04	72.13%	7.78E+04	68.80%	14.40	2.29	8.04
9 - 10	1.95E+07	36.57%	2.70E+05	41.06%	2.42E+04	76.76%	8.55E+04	73.28%	13.84	1.24	4.39
10 - 11	1.08E+08	66.90%	1.29E+06	68.44%	7.01E+04	90.16%	3.16E+05	89.82%	11.88	0.65	2.91
11 - 12	1.17E+08	99.69%	1.47E+06	99.65%	5.07E+04	99.86%	1.90E+05	99.80%	12.52	0.43	1.63
12 - 13	6.60E+05	99.88%	9.17E+03	99.85%	5.32E+02	99.96%	2.09E+03	99.91%	13.90	0.81	3.18
13 - 14	1.78E+05	99.93%	2.47E+03	99.90%	1.64E+02	99.99%	8.33E+02	99.95%	13.88	0.92	4.69
14 - 15	9.38E+03	99.93%	1.69E+02	99.90%	1.90E+00	99.99%	3.28E+01	99.95%	18.00	0.20	3.50
15 - 16	9.38E+03	99.93%	1.69E+02	99.91%	1.90E+00	99.99%	3.28E+01	99.96%	18.00	0.20	3.50
16 - 17	8.88E+04	99.96%	1.60E+03	99.94%	1.78E+01	99.99%	3.11E+02	99.97%	18.00	0.20	3.50
17 - 18	1.19E+05	99.99%	2.14E+03	99.99%	2.38E+01	100.00%	4.17E+02	99.99%	18.00	0.20	3.50
18 - 19	3.43E+04	100.00%	6.17E+02	100.00%	6.90E+00	100.00%	1.20E+02	100.00%	18.00	0.20	3.50
Global Total	3.57E+08		4.70E+06		5.23E+05		1.91E+06		13.16	1.47	5.34

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-10. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in October 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.46E+07	9.76%	4.20E+05	9.01%	1.81E+05	35.26%	6.25E+05	33.17%	12.15	5.23	18.07
1 - 2	9.38E+06	12.41%	1.52E+05	12.27%	2.88E+04	40.89%	1.05E+05	38.73%	16.19	3.07	11.16
2 - 3	8.74E+06	14.88%	1.49E+05	15.46%	2.34E+04	45.46%	8.81E+04	43.41%	17.01	2.68	10.08
3 - 4	1.01E+07	17.74%	1.84E+05	19.40%	2.22E+04	49.79%	8.08E+04	47.70%	18.14	2.19	7.97
4 - 5	9.41E+06	20.40%	1.59E+05	22.81%	2.29E+04	54.26%	8.11E+04	52.01%	16.85	2.43	8.62
5 - 6	9.20E+06	23.00%	1.48E+05	25.98%	2.30E+04	58.75%	8.09E+04	56.31%	16.11	2.50	8.79
6 - 7	9.26E+06	25.61%	1.47E+05	29.14%	2.25E+04	63.14%	7.60E+04	60.34%	15.88	2.43	8.20
7 - 8	9.98E+06	28.43%	1.50E+05	32.36%	2.34E+04	67.70%	8.23E+04	64.71%	15.04	2.34	8.24
8 - 9	9.56E+06	31.13%	1.38E+05	35.31%	2.17E+04	71.94%	7.67E+04	68.78%	14.41	2.27	8.02
9 - 10	1.92E+07	36.54%	2.65E+05	41.00%	2.39E+04	76.60%	8.43E+04	73.26%	13.83	1.25	4.40
10 - 11	1.08E+08	66.95%	1.28E+06	68.46%	6.91E+04	90.08%	3.12E+05	89.80%	11.89	0.64	2.89
11 - 12	1.16E+08	99.71%	1.45E+06	99.67%	5.00E+04	99.84%	1.88E+05	99.78%	12.54	0.43	1.62
12 - 13	6.18E+05	99.88%	8.52E+03	99.85%	5.97E+02	99.95%	2.24E+03	99.90%	13.78	0.97	3.62
13 - 14	1.62E+05	99.93%	2.25E+03	99.90%	1.85E+02	99.99%	9.02E+02	99.95%	13.93	1.14	5.58
14 - 15	9.38E+03	99.93%	1.69E+02	99.90%	1.90E+00	99.99%	3.28E+01	99.95%	18.00	0.20	3.50
15 - 16	9.38E+03	99.93%	1.69E+02	99.91%	1.90E+00	99.99%	3.28E+01	99.96%	18.00	0.20	3.50
16 - 17	8.88E+04	99.96%	1.60E+03	99.94%	1.78E+01	99.99%	3.11E+02	99.97%	18.00	0.20	3.50
17 - 18	1.19E+05	99.99%	2.14E+03	99.99%	2.38E+01	100.00%	4.17E+02	99.99%	18.00	0.20	3.50
18 - 19	3.43E+04	100.00%	6.17E+02	100.00%	6.90E+00	100.00%	1.20E+02	100.00%	18.00	0.20	3.50
Global Total	3.54E+08		4.66E+06		5.13E+05		1.88E+06		13.16	1.45	5.32

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-11. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in November 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.36E+07	9.70%	4.11E+05	8.97%	1.69E+05	34.60%	6.01E+05	33.09%	12.24	5.05	17.89
1 - 2	9.11E+06	12.34%	1.49E+05	12.21%	2.73E+04	40.17%	1.01E+05	38.66%	16.31	3.00	11.09
2 - 3	8.51E+06	14.80%	1.46E+05	15.39%	2.27E+04	44.81%	8.56E+04	43.37%	17.12	2.67	10.06
3 - 4	9.88E+06	17.65%	1.80E+05	19.33%	2.16E+04	49.21%	7.83E+04	47.68%	18.24	2.18	7.93
4 - 5	9.18E+06	20.30%	1.56E+05	22.73%	2.23E+04	53.75%	7.87E+04	52.02%	16.96	2.43	8.57
5 - 6	8.98E+06	22.90%	1.45E+05	25.90%	2.24E+04	58.31%	7.84E+04	56.33%	16.18	2.49	8.73
6 - 7	9.07E+06	25.52%	1.45E+05	29.06%	2.18E+04	62.77%	7.35E+04	60.39%	15.94	2.41	8.10
7 - 8	9.80E+06	28.35%	1.48E+05	32.29%	2.27E+04	67.40%	7.95E+04	64.76%	15.10	2.31	8.11
8 - 9	9.33E+06	31.05%	1.35E+05	35.24%	2.10E+04	71.68%	7.38E+04	68.83%	14.51	2.25	7.91
9 - 10	1.85E+07	36.41%	2.59E+05	40.90%	2.27E+04	76.33%	8.03E+04	73.25%	13.97	1.23	4.33
10 - 11	1.04E+08	66.48%	1.25E+06	68.10%	6.63E+04	89.85%	2.97E+05	89.63%	11.98	0.64	2.86
11 - 12	1.15E+08	99.72%	1.45E+06	99.69%	4.92E+04	99.89%	1.85E+05	99.84%	12.58	0.43	1.61
12 - 13	5.63E+05	99.89%	7.66E+03	99.85%	3.43E+02	99.96%	1.38E+03	99.91%	13.62	0.61	2.46
13 - 14	1.22E+05	99.92%	1.71E+03	99.89%	1.21E+02	99.99%	6.40E+02	99.95%	14.02	0.99	5.25
14 - 15	1.11E+04	99.92%	2.00E+02	99.90%	2.20E+00	99.99%	3.90E+01	99.95%	18.00	0.20	3.50
15 - 16	1.11E+04	99.93%	2.00E+02	99.90%	2.20E+00	99.99%	3.90E+01	99.95%	18.00	0.20	3.50
16 - 17	9.34E+04	99.95%	1.68E+03	99.94%	1.87E+01	99.99%	3.27E+02	99.97%	18.00	0.20	3.50
17 - 18	1.24E+05	99.99%	2.24E+03	99.99%	2.49E+01	100.00%	4.36E+02	99.99%	18.00	0.20	3.50
18 - 19	3.59E+04	100.00%	6.45E+02	100.00%	7.20E+00	100.00%	1.26E+02	100.00%	18.00	0.20	3.50
Global Total	3.46E+08		4.58E+06		4.90E+05		1.82E+06		13.24	1.42	5.25

Appendix C – Altitude Distribution of Fuel Burn and Emissions for Each Month of 1999

Table C-12. Fuel burned, emissions, cumulative fractions of emissions, and effective emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in December 1999.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	3.37E+07	9.62%	4.13E+05	8.90%	1.70E+05	34.44%	6.03E+05	32.99%	12.26	5.04	17.93
1 - 2	9.15E+06	12.23%	1.49E+05	12.12%	2.74E+04	40.00%	1.02E+05	38.56%	16.32	2.99	11.13
2 - 3	8.56E+06	14.68%	1.47E+05	15.28%	2.28E+04	44.63%	8.63E+04	43.28%	17.13	2.66	10.08
3 - 4	9.91E+06	17.51%	1.81E+05	19.18%	2.16E+04	49.01%	7.88E+04	47.58%	18.27	2.18	7.95
4 - 5	9.20E+06	20.14%	1.56E+05	22.55%	2.23E+04	53.54%	7.90E+04	51.90%	16.98	2.42	8.59
5 - 6	9.02E+06	22.71%	1.46E+05	25.70%	2.25E+04	58.10%	7.88E+04	56.21%	16.20	2.49	8.74
6 - 7	9.11E+06	25.32%	1.45E+05	28.84%	2.19E+04	62.55%	7.39E+04	60.25%	15.95	2.40	8.11
7 - 8	9.82E+06	28.12%	1.49E+05	32.04%	2.27E+04	67.16%	7.99E+04	64.62%	15.12	2.32	8.13
8 - 9	9.39E+06	30.80%	1.36E+05	34.99%	2.11E+04	71.44%	7.42E+04	68.68%	14.53	2.25	7.90
9 - 10	1.89E+07	36.19%	2.65E+05	40.71%	2.30E+04	76.12%	8.07E+04	73.09%	14.07	1.22	4.28
10 - 11	1.05E+08	66.30%	1.26E+06	67.96%	6.69E+04	89.70%	3.00E+05	89.49%	11.99	0.63	2.85
11 - 12	1.17E+08	99.69%	1.47E+06	99.66%	5.00E+04	99.84%	1.88E+05	99.79%	12.57	0.43	1.61
12 - 13	6.29E+05	99.87%	8.66E+03	99.84%	4.97E+02	99.94%	1.91E+03	99.89%	13.75	0.79	3.04
13 - 14	1.81E+05	99.93%	2.52E+03	99.90%	2.44E+02	99.99%	1.08E+03	99.95%	13.89	1.35	5.95
14 - 15	1.42E+04	99.93%	2.55E+02	99.90%	2.80E+00	99.99%	4.96E+01	99.95%	18.00	0.20	3.50
15 - 16	1.42E+04	99.93%	2.55E+02	99.91%	2.80E+00	99.99%	4.96E+01	99.96%	18.00	0.20	3.50
16 - 17	8.71E+04	99.96%	1.57E+03	99.94%	1.74E+01	99.99%	3.05E+02	99.97%	18.00	0.20	3.50
17 - 18	1.13E+05	99.99%	2.03E+03	99.99%	2.25E+01	100.00%	3.94E+02	99.99%	18.00	0.20	3.50
18 - 19	3.24E+04	100.00%	5.83E+02	100.00%	6.50E+00	100.00%	1.13E+02	100.00%	18.00	0.20	3.50
Global Total	3.50E+08		4.64E+06		4.93E+05		1.83E+06		13.25	1.41	5.23

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	9-13 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Airbus A300-600		**6,397.3**	**1.8%**		**17.8**	**10.1**	**2.0**	**12.2**	**1.7**	**0.3**	**1,675.9**	**3,953.9**
	A300-620R_PW4000-4158	2,854.1		44.6%	17.3	7.6	0.7	13.1	2.0	0.2	973.0	1,436.2
	A300-600R_CF6-80C2A5	2,419.1		37.8%	18.2	17.6	5.5	11.2	1.5	0.4	367.1	1,865.8
	A300-600_CF6-80C2A3	451.5		7.1%	17.7	12.4	3.6	13.0	1.3	0.3	142.4	250.1
	A300-620_JT9D-7R4H1	299.8		4.7%	21.1	5.2	0.7	13.1	2.0	0.4	121.3	134.9
	A300-600_FRT_CF6-80C2A5F	253.9		4.0%	17.0	6.6	0.7	13.1	1.2	0.3	52.9	174.3
	A300-620_PW4000-4158	62.8		1.0%	19.3	9.3	0.9	13.0	1.9	0.1	10.7	46.7
	A300-600R_CF6-80C2A5F	56.0		0.9%	16.9	18.0	5.2	11.3	1.3	0.3	8.5	45.8
Airbus A300-B2/B4/F4		**2,004.3**	**0.6%**		**22.2**	**13.1**	**5.2**	**14.5**	**1.9**	**1.2**	**523.6**	**1,273.5**
	A300-B4-200_CF6-50C2	649.2		32.4%	23.3	11.1	4.5	14.9	1.8	1.2	136.9	441.6
	A300-B2-100_CF6-50C	316.1		15.8%	22.2	10.7	4.3	14.5	2.0	1.2	91.1	182.2
	A300-B2-200_CF6-50C2R	225.2		11.2%	22.1	16.3	6.5	14.8	2.3	1.2	68.9	140.0
	A300-B4-120_JT9D-59A	213.8		10.7%	19.7	21.9	7.9	12.1	1.6	1.4	41.8	152.3
	A300-B2-200FF_CF6-50C2	163.5		8.2%	21.4	10.4	4.1	14.4	2.1	1.2	63.9	76.8
	A300-B2-200_CF6-50C2	143.1		7.1%	21.0	15.4	6.0	14.1	2.1	1.1	77.5	54.3
	A300-B4-200F_FRT_CF6-50C2	133.9		6.7%	23.5	10.7	4.3	15.1	1.7	1.1	19.6	105.0
	A300-F4-200_FRT_CF6-50C2	115.0		5.7%	24.6	10.6	4.3	15.1	1.7	1.1	14.0	93.0
	A300-B4-200FF_CF6-50C2	24.9		1.2%	24.4	11.7	4.7	14.5	2.0	1.2	5.0	16.8
	A300-B4-100_CF6-50C2	19.5		1.0%	24.4	12.0	4.8	14.4	2.1	1.2	4.9	11.6

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km Altitude Band EI (CO)	1-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Airbus A310		**5,297.5**	**1.5%**		**18.5**	**15.3**	**4.7**	**11.3**	**2.2**	**0.6**	**793.8**	**4,091.6**
	A310-300_CF6-80C2A2	1,583.2		29.9%	17.2	16.7	5.2	11.1	2.2	0.5	255.8	1,203.4
	A310-320_PW4000-4152	1,335.3		25.2%	17.9	17.7	5.6	11.2	2.2	0.5	177.1	1,057.2
	A310-300_CF6-80C2A8	1,022.6		19.3%	17.0	21.0	6.6	10.2	2.0	0.5	119.7	841.0
	A310-200_CF6-80A3	576.6		10.9%	19.2	5.8	1.3	12.8	2.9	0.7	114.5	408.5
	A310-200_CF6-80C2A2	293.2		5.5%	18.4	20.2	6.6	11.1	2.7	0.8	45.9	219.9
	A310-220_JT9D-7R4E1	194.7		3.7%	28.6	3.9	0.6	14.4	1.4	0.3	34.3	140.5
	A310-320_PW4000-4156A	179.8		3.4%	17.6	18.1	5.6	11.2	2.1	0.5	24.4	144.2
	A310-320_JT9D-7R4E1	112.1		2.1%	27.2	3.7	0.6	14.4	1.4	0.3	22.2	77.0
Airbus A319		**2,048.1**	**0.6%**		**14.6**	**5.7**	**0.7**	**10.9**	**2.5**	**0.3**	**655.4**	**1,164.9**
	A319-130_V2500-2522-A5	622.2		30.4%	15.9	5.5	0.1	10.9	2.5	0.1	132.6	447.9
	A319-110_CFM56-5A5	582.2		28.4%	14.0	4.8	0.5	10.2	2.1	0.5	190.0	330.2
	A319-110_CFM56-5B6_P	277.6		13.6%	16.0	8.3	1.6	11.7	2.5	0.5	65.1	182.8
	A319-110_CFM56-5A4	186.6		9.1%	12.3	3.9	0.5	9.8	2.4	0.4	147.8	0.4
	A319-110_CFM56-5B5_P	186.2		9.1%	16.5	9.0	1.9	11.5	3.1	0.7	49.5	110.8
	A319-110_CFM56-5B6_2P	120.9		5.9%	16.0	8.5	1.7	11.3	2.9	0.6	48.2	50.2
	A319-130_V2500-2524-A5	72.5		3.5%	15.1	5.0	0.1	10.7	2.5	0.1	22.2	42.6

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	9-13 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Airbus A320		**11,883.6**	**3.4%**		**17.5**	**5.6**	**0.5**	**12.0**	**2.0**	**0.4**	**3,233.9**	**7,284.7**
	A320-210_CFM56-5A1	5,882.1		49.5%	16.7	5.4	0.6	11.0	2.1	0.5	1,690.7	3,409.0
	A320-230_V2500-2527-A5	1,943.2		16.4%	16.6	6.2	0.1	11.5	2.1	0.1	412.6	1,373.1
	A320-230_V2500-2500-A1	1,927.9		16.2%	21.4	4.8	0.2	15.9	1.5	0.3	507.2	1,259.7
	A320-210_CFM56-5A3	791.1		6.7%	16.9	5.2	0.5	11.0	2.1	0.4	200.4	498.0
	A320-230_V2500-2527E-A5	344.6		2.9%	15.0	6.2	0.1	11.6	2.1	0.1	90.8	234.2
	A320-210_CFM56-5B4_2	327.8		2.8%	18.5	7.8	1.5	12.6	2.4	0.5	113.8	160.8
	A320-210_CFM56-5B4_P	281.9		2.4%	16.9	7.8	1.5	12.6	2.7	0.6	81.0	160.2
	A320-210_CFM56-5B4_2P	161.7		1.4%	15.9	6.7	1.3	12.6	2.8	0.6	64.9	73.4
	A320-210_CFM56-5B4	120.2		1.0%	16.7	5.4	0.6	11.0	2.2	0.5	34.4	69.3
	A320-110_CFM56-5A1	103.1		0.9%	16.7	5.5	0.6	11.3	2.4	0.5	38.0	47.0
Airbus A321		**1,405.1**	**0.4%**		**17.5**	**6.4**	**0.6**	**13.3**	**1.7**	**0.2**	**591.8**	**588.2**
	A321-110_CFM56-5B2	409.9		29.2%	18.2	11.2	1.4	13.5	1.8	0.3	129.7	226.3
	A321-210_CFM56-5B3_P	288.8		20.6%	17.4	3.6	0.1	13.4	1.9	0.1	162.7	74.2
	A321-130_V2500-2530-A5	229.9		16.4%	16.1	4.3	0.1	12.5	1.8	0.1	118.7	60.2
	A321-110_CFM56-5B1_2	228.8		16.3%	17.6	10.1	1.4	13.4	1.6	0.3	84.4	110.7
	A321-230_V2500-2533-A5	203.0		14.4%	17.7	3.7	0.1	13.4	1.7	0.1	86.0	86.7
	A321-210_CFM56-5B3_2P	44.8		3.2%	20.1	4.5	0.1	13.2	1.8	0.1	10.2	30.1

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	9-13 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Airbus A330-200		**847.9**	**0.2%**		**24.3**	**6.5**	**1.0**	**16.3**	**1.6**	**0.3**	**109.4**	**691.8**
	A330-220_PW4000-4168A	733.3		86.5%	24.5	6.7	1.0	16.9	1.8	0.1	98.5	593.9
	A330-240_Trent-772B-60	108.7		12.8%	22.4	4.0	0.7	12.9	0.7	1.2	10.2	93.1
	A330-200_CF6-80E1A4	5.8		0.7%	26.9	14.2	4.5	13.6	1.2	0.3	0.7	4.8
Airbus A330-300		**3,402.0**	**1.0%**		**23.0**	**7.0**	**1.5**	**14.5**	**1.3**	**0.5**	**690.4**	**2,387.9**
	A330-320_PW4000-4168	1,022.1		30.0%	24.2	6.9	1.2	16.1	1.8	0.2	202.6	719.2
	A330-300_CF6-80E1A2	840.5		24.7%	21.8	12.8	3.5	13.9	1.1	0.2	136.7	645.7
	A330-340_Trent-772-60	756.3		22.2%	22.1	3.6	0.7	13.0	0.8	1.1	172.3	499.0
	A330-320_PW4000-4164	420.6		12.4%	23.5	6.8	1.2	16.0	1.9	0.2	135.1	228.1
	A330-340_Trent-768-60	362.5		10.7%	23.7	3.6	0.6	13.3	0.7	1.1	43.6	295.9
Airbus A340-200		**910.4**	**0.3%**		**23.1**	**11.2**	**4.6**	**13.7**	**1.8**	**0.1**	**68.4**	**815.5**
	A340-210_CFM56-5C2	601.2		66.0%	23.1	11.1	4.6	13.8	1.8	0.1	44.1	539.3
	A340-210_CFM56-5C2G	176.9		19.4%	23.0	10.5	4.2	13.6	1.6	0.1	11.7	161.3
	A340-210_CFM56-5C3_F	132.3		14.5%	22.8	12.1	5.0	13.7	1.9	0.2	12.6	114.9
Airbus A340-300		**8,242.4**	**2.4%**		**23.0**	**11.3**	**4.7**	**13.7**	**1.7**	**0.2**	**706.4**	**7,228.7**
	A340-310_CFM56-5C4	4,989.6		60.5%	23.1	11.6	4.8	13.7	1.8	0.2	447.2	4,346.2
	A340-310_CFM56-5C2	2,658.9		32.3%	23.2	10.8	4.4	13.7	1.7	0.1	188.1	2,391.6
	A340-310_CFM56-5C3_F	594.0		7.2%	21.6	11.1	4.4	13.7	1.9	0.2	71.1	490.8
BAC111		**157.7**	**0.0%**		**14.4**	**25.5**	**15.1**	**10.1**	**14.7**	**6.0**	**57.9**	**73.1**
	One-Eleven-500_Spey-512-14DW	98.9		62.7%	14.1	26.2	15.4	10.2	14.9	6.2	39.2	43.6
	One-Eleven-560_Spey-512-14DW	58.9		37.3%	15.1	23.8	14.5	10.0	14.4	5.6	18.6	29.4

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km Altitude Band EI (CO)	1-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
BAE 146		**2,329.6**	**0.7%**		**9.1**	**5.0**	**0.5**	**7.8**	**1.6**	**0.1**	**927.3**	**950.5**
	146-200_ALF502-R-5	1,555.3		66.8%	9.1	5.0	0.4	7.7	1.6	0.1	624.1	616.3
	146-300_ALF502-R-5	432.9		18.6%	9.2	4.6	0.4	7.7	1.6	0.1	185.5	157.2
	146-100_ALF502-R-5	183.3		7.9%	9.1	4.9	0.4	7.8	1.6	0.1	57.7	98.7
	146-300_LF507-1H	137.6		5.9%	9.5	6.3	0.6	8.1	1.5	0.0	52.6	69.2
	146-300QT_FRT_ALF502-R-5	20.5		0.9%	9.1	4.6	0.4	7.7	1.6	0.1	7.4	9.0
Boeing 707		**606.8**	**0.2%**		**8.4**	**31.6**	**39.4**	**5.4**	**17.9**	**8.5**	**103.5**	**448.0**
	707-320C_FRT_JT3D-3B	482.8		79.6%	8.4	31.0	39.2	5.4	17.9	8.5	78.8	358.4
	707-320C_FRT_JT3D-7	77.1		12.7%	8.6	29.4	37.7	5.4	17.7	8.2	11.6	58.9
	707-320C_All_FRT_JT3D-3B	30.1		5.0%	7.7	35.9	38.0	5.5	16.1	7.0	7.1	21.1
	707-320C_JT3D-3B	16.8		2.8%	7.7	39.8	46.2	5.3	22.0	12.0	6.0	9.7
Boeing 727-100		**1,093.9**	**0.3%**		**10.8**	**14.8**	**5.7**	**7.1**	**10.2**	**2.1**	**374.7**	**485.8**
	727-100_JT8D-7B	462.6		42.3%	10.7	14.9	5.7	7.1	10.0	2.0	165.5	201.8
	727-100F_FRT_JT8D-7B	223.3		20.4%	10.8	14.7	6.0	7.1	10.6	2.3	69.8	95.5
	727-100QF_FRT_RB.183-651-54	199.2		18.2%	10.8	14.8	6.1	7.1	10.8	2.4	65.1	80.4
	727-100_JT8D-7	87.7		8.0%	10.7	15.3	5.5	7.0	11.1	2.5	41.6	33.8
	727-100C_JT8D-9	53.5		4.9%	11.3	15.0	5.0	7.2	8.4	1.6	15.6	34.7
	727-100C_CMB_JT8D-7B	35.0		3.2%	10.9	13.9	5.7	7.2	9.1	1.5	7.2	21.9
	727-100_JT8D-9	14.8		1.4%	11.9	14.4	5.0	7.2	8.9	1.8	4.5	8.4
	727-100F_FRT_JT8D-9	10.5		1.0%	12.2	14.1	5.2	7.1	9.5	2.0	2.9	5.4
	727-100C_CMB_JT8D-7	7.2		0.7%	10.7	15.0	5.6	7.2	9.7	1.9	2.4	3.9

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

					1-9 km Altitude Band			9-13 km Altitude Band				
Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Boeing 727-200		**14,333.8**	**4.1%**		**11.9**	**9.6**	**3.1**	**8.3**	**5.4**	**1.0**	**4,477.8**	**7,593.6**
	727-200_JT8D-15	8,271.9		57.7%	12.0	10.9	3.7	8.0	5.8	1.1	2,676.0	4,289.2
	727-200_JT8D-9A	2,451.8		17.1%	11.4	9.1	2.7	8.4	5.8	1.0	676.8	1,366.0
	727-200_JT8D-17R	1,546.4		10.8%	12.6	4.0	0.6	9.5	2.5	0.7	486.2	886.9
	727-200_JT8D-9	526.5		3.7%	11.4	9.3	2.7	8.5	6.2	1.1	203.3	199.1
	727-200F_FRT_JT8D-9	521.4		3.6%	11.3	9.3	2.7	8.4	5.9	1.0	159.5	261.5
	727-200F_FRT_JT8D-15	287.8		2.0%	12.1	10.6	3.6	8.0	5.6	1.1	81.3	164.9
	727-200F_FRT_JT8D-7	272.9		1.9%	11.3	9.4	2.8	8.4	5.8	1.0	78.7	151.3
	727-200_JT8D-17	181.4		1.3%	11.7	9.0	3.5	7.9	5.6	1.5	49.2	103.1
	727-200F_FRT_JT8D-17R	135.9		0.9%	12.8	3.4	0.5	10.1	2.1	0.6	36.4	76.3
	727-200_JT8D-7B	102.7		0.7%	11.4	8.9	2.6	8.4	6.0	0.9	20.8	71.8
	727-200F_FRT_JT8D-17	35.1		0.2%	11.6	10.7	4.0	7.9	5.7	1.5	9.6	23.5

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km Altitude Band EI (CO)	1-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Boeing 737-100/200		**12,222.7**	**3.5%**		**11.2**	**10.0**	**3.3**	**7.1**	**6.8**	**1.3**	**4,262.4**	**5,429.2**
	737-200_JT8D-9A	4,610.4		37.7%	10.7	11.6	3.5	7.1	7.8	1.2	1,581.4	2,043.6
	737-200_JT8D-15	2,513.9		20.6%	11.6	12.5	4.3	6.9	9.1	1.9	906.7	1,083.3
	737-200_JT8D-15A	1,583.0		13.0%	11.6	5.0	0.8	7.6	2.9	0.7	567.8	636.5
	737-200_JT8D-17	1,210.1		9.9%	11.3	11.2	4.3	6.8	9.0	2.4	445.5	538.0
	737-200C_QC_JT8D-17A	1,108.6		9.1%	11.5	4.8	2.5	7.4	3.0	0.8	322.7	570.4
	737-200_JT8D-17A	703.4		5.8%	11.4	5.0	2.6	7.5	3.1	0.8	254.6	335.6
	737-200C_CMB_JT8D-17	185.2		1.5%	11.4	10.9	4.2	6.8	8.9	2.4	60.7	84.1
	737-200_JT8D-9	107.3		0.9%	10.0	13.9	4.1	7.1	7.9	1.2	47.3	48.5
	737-200C_JT8D-9A	39.6		0.3%	10.8	11.0	3.4	7.0	7.9	1.2	12.5	19.1
	737-200C_JT8D-15	31.7		0.3%	11.0	14.2	4.7	7.1	10.5	2.6	18.9	8.1
	737-200QC_FRT_JT8D-9A	27.2		0.2%	10.8	10.7	3.2	7.0	7.8	1.2	8.0	13.8
	737-200C_JT8D-17A	23.0		0.2%	11.0	5.2	2.6	7.5	3.2	0.9	11.6	7.8
	737-200C_JT8D-17	22.1		0.2%	11.5	10.8	4.2	6.9	9.5	2.6	8.5	8.5
	737-200C_QC_JT8D-15A	15.3		0.1%	11.8	4.7	0.8	7.6	2.4	0.7	2.7	11.0
	737-200C_QC_JT8D-9	12.3		0.1%	10.3	17.1	6.2	7.1	7.7	1.2	5.1	4.9
	737-200QC_FRT_JT8D-15	11.3		0.1%	11.9	11.4	4.0	6.8	8.2	1.5	2.1	7.8
	737-200C_CMB_JT8D-9A	11.1		0.1%	10.9	11.4	3.5	7.0	7.9	1.2	3.4	5.0
	737-200_JT8D-7	4.7		0.0%	9.7	20.7	8.4	7.1	8.3	0.9	2.0	1.9
	737-200C_QC_JT8D-15	2.5		0.0%	11.8	12.0	4.3	6.8	9.1	1.8	0.8	1.3

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
Boeing 737-300/400/500		**30,764.9**	**8.9%**		**13.2**	**11.5**	**0.9**	**9.6**	**3.5**	**0.2**	**9,640.1**	**16,223.6**
	737-300_CFM56-3B1	14,158.7		46.0%	13.3	12.3	1.0	9.6	3.5	0.3	4,394.7	7,574.4
	737-400_CFM56-3C1	5,961.3		19.4%	13.5	11.1	0.8	9.6	3.5	0.2	1,745.8	3,218.5
	737-500_CFM56-3C1	3,442.2		11.2%	12.6	9.3	0.6	9.4	3.7	0.1	1,272.4	1,546.1
	737-500_CFM56-3B1	2,177.5		7.1%	12.7	9.8	0.6	9.4	3.6	0.1	721.1	1,103.9
	737-300_CFM56-3C1	2,169.3		7.1%	13.3	12.5	1.1	9.6	3.5	0.3	676.7	1,173.7
	737-300_CFM56-3B2	1,920.1		6.2%	13.4	12.0	1.0	9.6	3.3	0.2	565.6	1,084.9
	737-400_CFM56-3B2	923.9		3.0%	13.5	11.2	0.8	9.6	3.6	0.2	258.2	518.7
	737-300QC_QC_CFM56-3C1	12.2		0.0%	13.4	12.2	1.1	9.9	7.1	0.7	5.6	3.3
Boeing 737-600/700/800		**3,218.7**	**0.9%**		**16.3**	**6.4**	**0.9**	**11.8**	**1.8**	**0.3**	**818.2**	**2,032.0**
	737-800_CFM56-7B26	1,323.3		41.1%	18.4	5.6	0.6	12.7	1.3	0.3	278.8	911.3
	737-700_CFM56-7B22	832.1		25.9%	15.3	6.9	1.1	11.1	2.3	0.4	229.3	507.5
	737-700_CFM56-7B24	812.6		25.2%	15.4	6.9	1.1	11.2	2.2	0.3	209.6	511.8
	737-600_CFM56-7B20	217.1		6.7%	14.4	6.9	1.1	10.7	3.1	0.5	95.6	75.1
	737-800_CFM56-7B24	33.5		1.0%	18.6	6.1	0.8	12.2	1.5	0.3	4.8	26.3

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
Boeing 747-100/200/300		**30,638.2**	**8.8%**		**27.5**	**15.4**	**10.2**	**15.2**	**2.2**	**1.1**	**3,145.6**	**25,846.4**
	747-200B_JT9D-7Q	4,886.9		16.0%	23.6	14.7	7.1	12.7	0.7	0.7	406.5	29,978.8
	747-200SF_FRT_CF6-50E2	3,616.5		11.8%	27.2	14.6	10.2	16.1	1.7	1.5	351.6	21,530.8
	747-200F_FRT_CF6-50E2	3,061.5		10.0%	27.1	14.6	10.1	16.1	1.7	1.5	297.3	18,259.1
	747-200F_FRT_JT9D-7Q	2,904.3		9.5%	30.3	14.4	10.1	17.7	2.3	0.2	363.8	16,670.6
	747-100F_FRT_JT9D-7A	1,853.7		6.1%	26.6	15.3	10.0	15.2	0.6	0.8	254.5	10,340.6
	747-300_RB211-524D4	1,374.4		4.5%	31.4	24.4	22.5	15.8	8.3	2.6	132.4	8,262.5
	747-200B_CMB_CF6-50E2	1,293.0		4.2%	26.5	14.9	10.3	14.4	2.1	1.4	85.1	8,144.4
	747-200B_CF6-50E2	1,047.3		3.4%	25.3	14.4	9.8	14.6	2.0	1.4	78.5	6,511.8
	747-300_JT9D-7R4G2	1,029.6		3.4%	26.9	3.5	0.5	14.8	1.3	0.3	94.0	6,267.7
	747-200B_JT9D-7J	927.7		3.0%	28.1	20.2	13.7	16.1	3.1	0.6	120.9	5,308.3
	747-300_CF6-50E2	866.7		2.8%	27.3	14.5	10.1	14.9	1.9	1.4	60.1	5,430.1
	747-200F_FRT_JT9D-7J	860.9		2.8%	30.2	14.8	10.4	17.7	2.4	0.3	113.2	4,879.7
	747-100_JT9D-7A	722.9		2.4%	24.5	17.3	10.5	13.8	0.6	0.9	87.2	4,140.3
	747-200B_RB211-524D4	654.6		2.1%	31.0	24.6	22.9	15.0	9.2	2.8	57.5	3,963.4
	747-200F_FRT_RB211-524D4	641.0		2.1%	37.7	3.7	0.8	21.5	1.6	0.8	71.6	3,732.6
	747-300_CF6-80C2B1	600.0		2.0%	25.2	14.6	4.5	12.1	1.3	0.3	38.9	3,806.0
	747-200B_JT9D-7R4G2	534.8		1.7%	27.1	4.0	0.6	14.2	1.3	0.3	42.9	3,360.6
	747-200B_JT9D-7A	443.4		1.4%	25.1	17.4	10.5	13.3	0.6	0.9	60.4	2,475.2
	747-100_JT9D-7	366.3		1.2%	25.1	15.1	9.2	13.3	0.4	0.7	33.6	2,219.4
	747-200SF_FRT_RB211-524D4	354.4		1.2%	32.8	21.2	19.3	18.0	6.3	2.0	37.5	2,096.2
	747-300_CMB_CF6-50E2	291.7		1.0%	26.2	16.4	11.1	14.7	2.1	1.6	30.1	1,734.3
	747-300_CMB_JT9D-7R4G2	249.4		0.8%	28.4	3.7	0.6	14.6	1.4	0.3	19.7	1,544.1
	747-SP_RB211-524D4	236.1		0.8%	28.2	24.6	21.1	15.2	9.3	3.1	22.7	1,086.4
	747-100B_SR_JT9D-7A	199.8		0.7%	28.4	20.2	12.2	12.2	1.3	1.8	66.6	665.3
	747-200C_F_FRT_CF6-50E2	196.1		0.6%	26.9	15.5	10.7	15.8	1.9	1.6	22.1	1,132.2
	747-SP_JT9D-7F	191.3		0.6%	25.1	29.9	20.7	15.6	3.8	1.6	28.7	629.7

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km Altitude Band EI (CO)	1-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Boeing 747-100/200/300 (Continued)												
	747-200SF_FRT_JT9D-7J	164.6		0.5%	30.2	14.8	10.4	17.4	2.4	0.3	21.1	938.6
	747-300_RB211-524C2	143.9		0.5%	33.7	4.8	0.8	18.4	2.0	0.9	32.1	651.7
	747-100B_RB211-524C2	131.5		0.4%	25.0	26.9	25.3	14.1	11.0	2.3	15.3	755.0
	747-200F_FRT_JT9D-7R4G2	127.1		0.4%	28.6	16.5	10.1	17.3	2.4	0.3	19.4	729.8
	747-SP_JT9D-7J	109.7		0.4%	24.4	22.1	13.5	13.3	1.3	1.7	18.5	554.3
	747-SP_JT9D-7FW	84.5		0.3%	25.9	29.3	20.3	16.2	2.8	0.6	9.9	476.3
	747-200B_CMB_CF6-50E	84.0		0.3%	24.5	18.2	11.9	13.7	2.4	1.6	8.4	501.0
	747-200B_JT9D-7Q3	82.7		0.3%	22.9	14.8	6.2	12.9	0.6	0.6	6.2	528.1
	747-200B_CMB_JT9D-7Q	72.8		0.2%	20.9	14.5	6.2	11.9	0.8	0.7	9.5	407.4
	747-SR-100B_CF6-45A2	70.7		0.2%	24.1	12.9	10.1	14.2	2.8	1.6	5.5	436.5
	747-200C_QC_CF6-50E2	50.5		0.2%	26.6	14.2	9.9	14.6	2.0	1.4	3.1	320.8
	747-SP_JT9D-7A	49.4		0.2%	24.2	22.8	13.9	13.8	4.1	4.4	9.3	104.8
	747-200B_JT9D-7F	25.8		0.1%	27.0	21.9	13.8	16.2	2.6	0.5	3.5	150.5
	747-300_CMB_CF6-80C2B1	22.7		0.1%	20.4	20.2	6.3	11.5	2.1	0.5	3.0	125.6
	747-200B_JT9D-70A	14.2		0.0%	22.0	26.3	13.7	13.2	1.1	1.4	3.6	74.8
Boeing 747-400		**59,837.4**	**17.2%**		**25.3**	**8.1**	**1.9**	**13.3**	**1.0**	**0.4**	**4,440.3**	**52,982.2**
	747-400_CF6-80C2B1F	20,215.2		33.8%	20.4	13.6	3.6	11.6	1.3	0.3	1,695.1	17,580.1
	747-400_PW4000-4056	15,590.5		26.1%	22.8	3.0	0.3	14.0	0.6	0.3	1,104.1	13,881.3
	747-400_RB211-524H2	11,341.7		19.0%	41.0	2.8	0.5	15.7	1.2	0.6	729.1	10,233.3
	747-400_CMB_CF6-80C2B1F	6,249.3		10.4%	21.0	13.7	3.7	11.6	1.3	0.3	446.8	5,566.3
	747-400_RB211-524G	2,605.1		4.4%	39.2	2.9	0.5	15.1	0.9	0.6	150.5	2,371.8
	747-400F_FRT_PW4000-4056	1,428.0		2.4%	23.2	2.9	0.3	14.4	0.5	0.3	126.2	1,234.2
	747-400_CMB_PW4000-4056	1,234.9		2.1%	22.5	3.2	0.3	13.8	0.6	0.3	101.9	1,073.6
	747-400F_FRT_CF6-80C2B1F	888.7		1.5%	20.0	1.5	0.2	13.1	0.5	0.1	62.5	794.3
	747-400F_FRT_RB211-524H2	284.0		0.5%	38.4	6.4	0.5	16.4	1.3	0.6	24.0	247.3

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km Altitude Band EI (CO)	1-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Boeing 757-200		**19,716.7**	**5.7%**		**18.6**	**8.4**	**0.5**	**11.0**	**1.7**	**0.1**	**3,916.9**	**13,810.7**
	757-200_PW2000-2037	8,508.8		43.2%	17.3	6.7	0.6	12.1	1.6	0.1	1,850.0	5,841.9
	757-200_RB211-535E4B	4,171.6		21.2%	22.6	9.9	0.2	10.1	1.8	0.0	509.3	3,335.7
	757-200_RB211-535E4	4,054.2		20.6%	20.7	9.2	0.2	10.1	1.6	0.0	736.9	2,880.2
	757-200_PW2000-2040	1,036.0		5.3%	18.1	7.2	0.6	12.1	1.5	0.1	198.7	748.5
	757-200_RB211-535C	960.9		4.9%	15.8	12.7	0.6	9.8	3.3	0.5	387.5	381.4
	757-200PF_FRT_RB211-535E4	947.8		4.8%	19.4	8.8	0.2	10.2	1.6	0.0	230.1	590.8
	757-200PF_FRT_PW2000-2040	37.5		0.2%	18.2	8.1	0.7	12.1	1.2	0.1	4.4	32.1
Boeing 767-200		**7,110.2**	**2.0%**		**22.6**	**6.6**	**1.6**	**11.1**	**2.0**	**0.3**	**959.5**	**5,693.3**
	767-200_JT9D-7R4D	1,883.5		26.5%	24.0	2.0	0.3	11.2	1.9	0.3	269.6	1,496.3
	767-200ER_CF6-80A	1,260.8		17.7%	19.8	16.9	4.7	10.0	1.9	0.4	108.0	1,093.4
	767-200ER_CF6-80C2B2	830.7		11.7%	18.7	16.5	4.8	10.0	1.8	0.4	71.8	723.8
	767-200_CF6-80A	678.8		9.5%	20.9	5.3	1.2	12.2	3.4	0.6	195.2	390.9
	767-200EM_JT9D-7R4D	566.7		8.0%	26.8	1.8	0.3	11.3	1.8	0.3	49.6	491.9
	767-200ER_PW4000-4056	336.1		4.7%	18.7	9.3	0.9	12.3	1.8	0.1	26.9	303.6
	767-200ER_JT9D-7R4E	302.2		4.3%	28.2	2.1	0.4	13.4	1.5	0.3	86.9	166.6
	767-200ER_CF6-80C2B4	285.1		4.0%	19.5	16.0	4.4	10.0	2.0	0.3	19.1	256.5
	767-200ER_JT9D-7R4E4	266.7		3.8%	22.8	3.7	0.8	11.4	1.7	0.4	51.1	189.2
	767-200ERM_JT9D-7R4E	197.6		2.8%	27.3	2.7	0.4	13.8	1.2	0.3	25.8	164.7
	767-200_CF6-80C2B2F	164.9		2.3%	19.4	18.5	5.2	10.2	2.5	0.6	25.1	124.8
	767-200EM_CF6-80A2	123.8		1.7%	22.2	4.4	1.0	12.6	2.8	0.6	8.9	111.0
	767-200PC_FRT_CF6-80A	114.8		1.6%	22.1	5.1	1.2	12.2	3.2	0.6	15.7	90.9
	767-200ER_CF6-80C2B4F	98.5		1.4%	20.3	14.8	4.1	10.3	1.6	0.3	5.7	89.8

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km EI (CO)	1-9 km EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km EI (CO)	9-13 km EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Boeing 767-300		**22,152.7**	**6.4%**		**21.3**	**7.0**	**1.4**	**12.5**	**1.2**	**0.3**	**3,207.2**	**17,470.8**
	767-300ER_PW4000-4060	9,192.1		41.5%	21.5	3.6	0.3	13.4	0.7	0.3	1,008.1	7,743.6
	767-300ER_CF6-80C2B6	4,240.2		19.1%	19.3	16.4	4.3	10.6	1.7	0.3	384.1	3,664.0
	767-300ER_CF6-80C2B6F	2,595.5		11.7%	17.6	5.4	0.5	12.5	1.1	0.1	253.8	2,222.6
	767-300_CF6-80C2B2	1,779.9		8.0%	19.4	5.9	1.4	13.3	3.1	0.8	667.0	810.1
	767-300ER_RB211-524H3	965.4		4.4%	35.6	8.5	0.6	14.9	1.7	0.7	200.5	666.5
	767-300ERF_FRT_CF6-80C2B6F	659.8		3.0%	19.1	16.6	4.4	10.8	2.1	0.5	112.1	491.7
	767-300_JT9D-7R4D	603.5		2.7%	24.2	2.4	0.4	14.7	1.4	0.3	243.3	253.8
	767-300ER_CF6-80C2B4	588.7		2.7%	18.2	15.1	4.1	10.5	2.1	0.4	82.3	465.4
	767-300ER_PW4000-4056	374.1		1.7%	21.6	3.8	0.3	13.2	0.7	0.3	44.7	308.3
	767-300_CF6-80C2B2F	363.1		1.6%	18.8	5.6	1.3	13.2	2.8	0.7	101.4	213.6
	767-300ER_CF6-80C2B7F	226.9		1.0%	17.8	5.6	0.5	12.4	1.2	0.1	22.0	193.4
	767-300ER_CF6-80C2B2	224.0		1.0%	18.7	17.4	5.0	10.7	1.7	0.5	25.1	188.8
	767-300ER_PW4000-4062	100.6		0.5%	22.0	3.7	0.3	13.0	0.7	0.3	10.7	84.7
	767-300ER_RB211-524H2	89.0		0.4%	33.8	10.2	0.6	14.9	1.9	0.7	20.3	64.0
	767-300_PW4000-4056	52.7		0.2%	21.8	7.0	1.8	13.5	3.4	0.9	13.9	30.9
	767-300_CF6-80C2B4F	52.1		0.2%	21.9	6.9	1.7	13.1	3.1	0.8	12.3	32.9
	767-300ERF_FRT_CF6-80C2B7F	45.0		0.2%	19.7	16.3	4.3	10.8	1.8	0.4	5.6	36.4
Boeing 777-200		**11,260.1**	**3.2%**		**25.2**	**5.4**	**6.0**	**16.8**	**0.6**	**0.3**	**1,416.7**	**9,244.0**
	777-200ER_PW4000-4090	3,183.9		28.3%	26.7	5.6	0.8	16.0	0.3	0.2	306.7	2,766.0
	777-200ER_GE90-92B	2,676.6		23.8%	28.9	4.1	0.2	20.3	0.8	0.1	320.2	2,209.3
	777-200ER_Trent-892	2,018.6		17.9%	21.4	8.4	24.0	13.4	0.7	0.4	178.3	1,758.3
	777-200ER_GE90-85B	1,392.7		12.4%	26.4	4.2	0.2	19.4	0.7	0.1	127.5	1,211.8
	777-200_PW4000-4074	672.7		6.0%	23.1	3.5	0.6	16.1	0.6	0.2	247.6	328.7
	777-200ER_Trent-884	642.0		5.7%	21.0	8.9	25.4	13.3	0.8	0.8	72.8	533.7
	777-200_Trent-875	352.0		3.1%	21.0	9.9	28.6	13.4	1.3	1.6	66.5	251.6
	777-200_PW4000-4077	321.6		2.9%	24.6	4.0	0.7	16.2	0.7	0.3	97.0	184.6

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km Altitude Band EI (CO)	1-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Boeing 777-300		**1,131.0**	**0.3%**		**24.8**	**4.4**	**10.3**	**15.7**	**0.8**	**0.5**	**264.3**	**756.3**
	777-300_Trent-892	767.1		67.8%	24.8	6.8	23.6	15.3	0.8	0.7	115.9	597.8
	777-300_PW4000-4090	363.9		32.2%	24.7	2.5	0.0	17.2	0.9	0.0	148.4	158.5
Concorde		**351.2**	**0.1%**		**11.0**	**18.5**	**1.3**	**10.0**	**26.1**	**1.8**	**45.4**	**18.1**
	concorde	351.2		100%	11.0	18.5	1.3	10.0	26.1	1.8	45.4	18.1
DC-10		**12,679.4**	**3.6%**		**24.2**	**7.5**	**2.8**	**14.9**	**2.0**	**0.9**	**1,558.1**	**10,454.0**
	DC-10-30_CF6-50C2	4,477.6		35.3%	24.6	10.2	4.1	12.9	2.7	1.3	382.4	3,899.4
	DC-10-40_JT9D-20	2,827.2		22.3%	23.0	5.8	1.9	14.6	0.2	0.4	355.8	2,324.7
	DC-10-10_CF6-6K	1,302.1		10.3%	29.4	7.0	2.6	20.5	2.2	0.7	160.0	1,070.2
	DC-10-30_CF6-50C	896.6		7.1%	23.4	10.5	4.2	13.0	3.3	1.4	104.7	740.7
	DC-10-10F_FRT_CF6-6D	745.9		5.9%	28.4	6.8	2.5	21.0	2.0	0.6	132.9	559.5
	DC-10-40I_JT9D-59A	610.7		4.8%	17.3	4.0	1.0	12.0	0.7	0.4	120.5	439.5
	DC-10-10_CF6-6D	607.7		4.8%	28.9	8.6	3.1	20.1	2.4	0.8	100.8	468.3
	DC-10-30F_FRT_CF6-50C2	591.5		4.7%	19.6	4.8	2.2	15.1	1.8	1.1	139.7	426.1
	DC-10-30CF_CF6-50C2	507.5		4.0%	24.7	11.1	4.4	12.5	3.0	1.4	53.7	424.4
	DC-10-30_CF6-50C2R	95.8		0.8%	25.2	9.4	3.8	13.0	2.6	1.3	6.5	86.1
	DC-10-30_CF6-50C1	16.8		0.1%	25.2	9.3	3.8	13.0	2.6	1.2	1.1	15.1

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km EI (CO)	1-9 km EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km EI (CO)	9-13 km EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
DC-8		**2,882.7**	**0.8%**		**11.2**	**16.3**	**11.2**	**8.6**	**7.2**	**1.4**	**645.0**	**1,962.5**
	DC-8-71F_FRT_CFM56-2C1	1,111.6		38.6%	12.9	8.4	0.5	10.2	2.9	0.2	244.6	774.7
	DC-8-63_FRT_JT3D-7	589.6		20.5%	8.2	32.0	28.6	5.7	14.0	2.2	136.5	386.2
	DC-8-73CF_FRT_CFM56-2C1	563.1		19.5%	13.0	8.2	0.5	10.1	3.2	0.2	139.8	366.2
	DC-8-73F_FRT_CFM56-2C1	188.9		6.6%	13.3	7.3	0.4	10.3	2.4	0.2	28.1	149.5
	DC-8-54CF_FRT_JT3D-3B	142.1		4.9%	9.1	26.0	33.1	5.8	14.6	6.8	34.5	91.4
	DC-8-61C_FRT_JT3D-3B	134.6		4.7%	7.5	30.9	33.9	5.0	23.3	7.0	35.8	80.2
	DC-8-63CF_FRT_JT3D-7	97.8		3.4%	8.3	30.4	27.0	5.7	13.1	1.8	18.3	71.0
	DC-8-62CF_FRT_JT3D-3B	54.9		1.9%	8.1	27.7	32.7	5.2	20.5	6.0	7.3	43.4
DC-9		**9,130.1**	**2.6%**		**11.0**	**11.8**	**4.2**	**7.6**	**6.7**	**1.0**	**3,910.8**	**3,619.6**
	DC-9-31_JT8D-7B	2,496.5		27.3%	10.6	13.0	5.0	7.4	7.9	0.9	1,071.2	956.2
	DC-9-32_JT8D-9A	1,678.0		18.4%	10.5	13.3	4.7	7.4	7.4	1.1	655.6	759.6
	DC-9-31_JT8D-9A	1,272.3		13.9%	10.9	7.1	1.4	7.7	2.1	0.4	602.0	402.1
	DC-9-51_JT8D-17	1,080.7		11.8%	12.5	9.9	4.0	8.1	5.8	1.6	492.9	356.7
	DC-9-41_FRT_JT8D-11	557.9		6.1%	12.8	12.4	4.3	8.3	6.5	0.9	214.3	261.0
	DC-9-15_JT8D-7A	380.6		4.2%	9.4	16.5	6.1	7.4	7.8	0.9	157.6	191.8
	DC-9-41_JT8D-11	325.2		3.6%	13.0	11.9	4.1	8.3	6.7	0.9	142.4	121.7
	DC-9-32_JT8D-7A	249.8		2.7%	10.2	14.0	5.3	7.4	8.0	1.0	102.9	111.2
	DC-9-32_JT8D-7B	247.9		2.7%	10.3	13.6	5.2	7.4	7.9	0.9	108.8	96.8
	DC-9-32_JT8D-17	208.0		2.3%	9.4	14.4	5.3	7.1	7.3	1.8	94.0	95.2
	DC-9-31_JT8D-7A	173.1		1.9%	10.7	12.5	4.8	7.4	7.8	0.9	52.3	97.3
	DC-9-51_JT8D-17A	153.0		1.7%	12.5	4.8	2.8	8.6	2.4	0.6	76.7	42.7
	DC-9-41_JT8D-15	68.4		0.7%	12.7	11.5	4.3	8.2	5.4	0.9	23.8	34.8
	DC-9-21_JT8D-11	67.6		0.7%	10.9	13.4	5.4	7.2	7.4	1.3	26.3	30.6
	DC-9-15_JT8D-7	48.4		0.5%	8.8	18.5	6.7	7.4	8.2	1.0	27.8	17.8
	DC-9-32_JT8D-11	41.2		0.5%	9.3	15.6	5.4	7.2	8.4	1.0	26.5	10.2
	DC-9-32_JT8D-9	34.7		0.4%	10.6	13.0	4.7	7.5	7.5	1.2	17.0	10.1

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km EI (CO)	1-9 km EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km EI (CO)	9-13 km EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
DC-9 (Continued)												
	DC-9-31CF_JT8D-17	24.1		0.3%	8.8	15.8	5.7	7.2	6.9	1.7	8.6	14.6
	DC-9-15RC_FRT_JT8D-7B	11.4		0.1%	9.8	15.8	5.9	7.4	8.1	1.0	5.3	4.7
	DC-9-33CF_JT8D-9A	11.3		0.1%	10.7	12.7	4.5	7.4	7.6	1.2	4.7	4.5
Fokker 100		**3,444.1**	**1.0%**		**11.1**	**21.0**	**2.0**	**6.4**	**7.0**	**1.0**	**1,319.4**	**1,413.6**
	100-*_RB.183-650-15	3,062.2		88.9%	10.8	21.7	1.9	6.2	7.3	1.0	1,170.2	1,273.4
	100-*_RB.183-620-15	381.8		11.1%	13.3	14.9	2.0	8.2	4.2	1.2	149.3	140.2
Fokker 28		**1,210.7**	**0.3%**		**10.5**	**13.5**	**7.8**	**7.4**	**7.2**	**2.7**	**601.0**	**362.1**
	F.28-4000_Spey-555-15P	994.7		82.2%	10.5	13.6	7.9	7.4	7.1	2.6	481.1	320.2
	F.28-1000_Spey-555-15	110.8		9.2%	10.4	14.3	8.6	7.5	7.5	2.8	63.4	20.0
	F.28-3000_Spey-555-15H	51.1		4.2%	10.4	12.4	6.8	7.5	6.8	2.6	24.6	17.2
	F.28-2000_Spey-555-15	40.9		3.4%	10.6	12.0	5.2	7.7	8.4	3.3	24.9	3.2
	F.28-4000_Spey-555-15H	13.2		1.1%	10.6	13.3	7.0	7.4	7.5	2.7	7.0	1.4
Fokker 70		**452.5**	**0.1%**		**10.3**	**5.3**	**1.2**	**7.1**	**2.7**	**1.0**	**202.2**	**153.4**
	70-*_RB.183-620-15	452.5		100.0%	10.3	5.3	1.2	7.1	2.7	1.0	202.2	153.4
Lockheed L-1011		**2,415.5**	**0.7%**		**18.7**	**19.4**	**13.6**	**14.4**	**9.0**	**2.2**	**518.3**	**1,676.1**
	L-1011-1_RB211-22B	1,689.9		70.0%	18.3	18.6	13.7	14.7	6.8	1.8	409.1	1,115.8
	L-1011-500_RB211-524B4	463.9		19.2%	20.5	24.9	13.0	12.8	17.4	3.8	67.5	361.6
	L-1011-200_FRT_RB211-524B	121.8		5.0%	20.8	17.8	14.2	15.3	6.0	1.4	20.8	91.0
	L-1011-50_RB211-22B	108.7		4.5%	19.6	17.4	13.3	14.7	6.5	1.6	14.6	86.0
	L-1011-200_FRT_RB211-524B4	23.7		1.0%	20.5	19.0	15.2	14.6	7.0	1.9	5.3	15.7
	L11_Blank-Blank	7.5		0.3%	21.6	18.0	14.4	14.8	6.5	1.6	1.0	6.0

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km Altitude Band EI (CO)	1-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
MD-11		**11,951.7**	**3.4%**		**19.0**	**5.9**	**0.5**	**12.9**	**1.2**	**0.1**	**1,003.6**	**10,448.6**
	MD-11-Passenger_CF6-80C2D1F	4,268.4		35.7%	18.9	4.1	0.4	12.7	1.0	0.1	346.8	3,757.6
	MD-11-Freighter_FRT_CF6-80C2D1F	2,941.4		24.6%	17.5	5.0	0.5	13.6	0.8	0.1	278.5	2,515.7
	MD-11-Passenger_PW4000-4460	2,293.2		19.2%	20.2	8.9	0.8	12.4	1.8	0.2	195.8	1,994.1
	MD-11-Passenger_PW4000-4462	1,621.5		13.6%	20.4	8.3	0.7	12.5	1.8	0.2	120.5	1,446.5
	MD-11-Combi_CMB_CF6-80C2D1F	450.3		3.8%	17.4	3.9	0.4	12.8	1.0	0.1	28.6	409.6
	MD-11-Freighter_FRT_PW4000-4460	310.5		2.6%	22.0	9.1	1.6	14.3		1.3	28.1	266.7
	MD-11-CF_QC_PW4000-4462	33.2		0.3%	20.8	8.0	0.7	12.4	1.7	0.1	1.9	30.3
	MD-11-CF_QC_PW4000-4460	33.0		0.3%	19.3	8.5	0.7	12.0	2.0	0.2	3.3	28.0
MD-80		**22,366.8**	**6.4%**		**16.0**	**4.2**	**1.2**	**10.6**	**4.4**	**1.6**	**6,712.7**	**12,352.9**
	MD-80-82_JT8D-217C	8,751.6		39.1%	16.4	4.0	1.1	10.7	4.3	1.6	2,301.6	5,213.2
	MD-80-83_JT8D-219	5,047.2		22.6%	15.6	4.2	1.3	10.6	4.3	1.6	1,582.1	2,780.5
	MD-80-88_JT8D-219	3,736.1		16.7%	15.4	4.3	1.3	10.6	4.3	1.6	1,348.8	1,847.1
	MD-80-82_JT8D-217A	1,894.9		8.5%	16.4	4.1	1.1	10.7	4.4	1.6	512.8	1,102.0
	MD-80-81_JT8D-217C	932.0		4.2%	16.4	4.1	1.2	10.7	4.6	1.6	372.5	334.9
	MD-80-87_JT8D-217C	777.5		3.5%	15.6	4.5	1.3	9.7	5.2	1.9	231.7	404.8
	MD-80-81_JT8D-217	664.2		3.0%	16.4	4.0	1.1	10.6	4.5	1.6	200.3	351.2
	MD-80-82_JT8D-217	354.1		1.6%	16.3	4.1	1.2	10.6	4.4	1.6	89.7	217.1
	MD-80-87_JT8D-219	173.4		0.8%	15.3	4.9	1.4	9.8	5.0	1.9	54.4	94.5
	MD-80-83_JT8D-217C	36.0		0.2%	14.4	4.1	1.3	10.4	4.5	1.7	18.8	7.6
MD-90		**1,242.9**	**0.4%**		**16.4**	**5.2**	**0.1**	**11.9**	**1.8**	**0.1**	**510.4**	**543.2**
	MD-90-30_V2500-2525-D5	637.5		51.3%	16.4	4.9	0.1	11.8	1.9	0.1	272.7	243.3
	MD-90-30_V2500-2528-D5	605.3		48.7%	16.5	5.6	0.1	11.9	1.8	0.1	237.7	299.8

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	1-9 km EI (CO)	1-9 km EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km EI (CO)	9-13 km EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Miscellaneous		**5.4**	**0.0%**		**8.6**	**15.8**	**2.3**	**7.3**	**0.8**	**0.2**	**2.3**	**2.3**
	DFL_Blank-Blank	3.8		70.3%	8.5	16.0	2.2	7.3	0.7	0.2	1.6	1.7
	LRJ_Blank-Blank	1.6		29.7%	8.9	15.3	2.4	7.3	1.2	0.2	0.7	0.6
Regional Jets		**4,479.0**	**1.3%**		**11.6**	**9.4**	**1.4**	**9.1**	**0.6**	**0.1**	**1,907.1**	**1,663.8**
	CRJ-100ER_CF34-3A1	1,693.0		37.8%	8.7	13.4	2.0	7.3	0.7	0.2	724.3	639.7
	RJ-RJ85_LF507-1F	905.9		20.2%	18.0	1.0	0.0	12.8	0.5	0.0	381.4	314.6
	EMJ_Blank-Blank	561.3		12.5%	8.7	13.0	2.0	7.3	0.6	0.2	238.8	208.8
	RJ-RJ100_LF507-1F	351.7		7.9%	17.8	1.0	0.0	13.9	0.4	0.0	163.9	120.0
	CRJ-100LR_CF34-3A1	266.5		6.0%	8.8	13.8	2.1	7.3	0.7	0.2	102.6	113.4
	CRJ-200LR_CF34-3B1	216.9		4.8%	8.7	13.3	2.1	7.3	0.6	0.2	85.2	91.5
	RJ-RJ70_LF507-1F	149.2		3.3%	18.7	1.0	0.0	12.8	0.5	0.0	55.7	66.0
	ERJ-145-ER_AE-A	144.9		3.2%	8.6	11.5	1.8	7.3	0.7	0.2	82.6	30.0
	CRJ-200ER_CF34-3B1	92.9		2.1%	8.8	14.4	2.2	7.3	0.8	0.2	35.7	38.7
	ERJ-145-EP_AE-A	65.0		1.5%	8.7	12.8	1.9	7.3	0.4	0.2	23.4	29.4
	ERJ-145-EP_AE-A1_1	24.1		0.5%	8.7	13.0	2.0	7.3	0.5	0.2	10.0	9.3
	ERJ-145-LR_AE-A1	7.6		0.2%	8.6	12.3	1.9	7.3	0.7	0.2	3.6	2.5

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	9-13 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Russian Aircraft		**7,138.3**	**2.1%**		**12.3**	**15.5**	**9.0**	**9.2**	**8.4**	**1.5**	**1,351.6**	**5,045.7**
	Tu-154-B_NK-8-2U	1,954.6		27.4%	12.2	9.6	3.3	8.2	5.2	0.9	385.7	1,353.8
	Il-62-M_D-30-KU	1,404.5		19.7%	15.5	7.8	2.3	9.5	4.8	0.8	139.4	1,204.8
	Tu-154-M_D-30-KU-154-II	1,008.6		14.1%	12.2	9.8	3.3	8.0	5.5	1.0	224.1	657.4
	Il-86-*_NK-86	653.5		9.2%	19.5	30.6	26.4	14.3	13.3	2.3	105.9	495.2
	Tu-134-A_D-30-3	534.5		7.5%	10.7	12.3	4.7	7.4	7.7	0.9	157.0	311.0
	Il-76-T_FRT_D-30-KP-2	374.7		5.2%	15.2	9.2	2.7	8.7	5.7	0.9	58.4	287.7
	Il-96-300_PS-90-A	240.4		3.4%	21.3	14.5	11.3	15.5	5.8	1.3	21.0	211.0
	Yak-40-*_AI-25	147.5		2.1%	5.7	37.1	29.1	4.0	46.7	10.4	54.0	50.1
	Tu-134-A_D-30-2	143.2		2.0%	10.7	12.4	4.8	7.4	7.8	0.9	44.1	80.0
	Yak-42-*_D-36	124.3		1.7%	5.7	36.3	28.1	4.0	46.0	8.1	31.0	67.6
	Yak-40-*_AI-25-Blank	92.7		1.3%	5.7	40.5	32.3	4.0	46.2	10.1	38.6	26.5
	Yak-42-D_D-36	92.0		1.3%	5.6	36.5	28.4	4.1	44.5	8.0	24.7	46.6
	Yak-42-D_D-36	92.0		1.3%	5.6	36.5	28.4	4.1	44.5	8.0	24.7	46.6
	Yak-42-*_D-36-Blank	68.7		1.0%	5.7	36.0	27.8	4.1	43.8	7.0	14.8	42.5
	Il-62-*_NK-8-4	67.4		0.9%	15.3	8.7	2.6	8.8	5.5	0.8	9.0	54.4
	An-124-*_FRT_D-18-T	59.2		0.8%	22.5	4.9	1.2	11.5	1.0	0.2	6.1	49.4
	Il-86-*_NK-86-Blank	48.9		0.7%	19.8	28.5	24.3	14.5	12.7	2.0	6.1	39.9
	Tu-134-B_D-30-3	16.3		0.2%	10.5	12.8	4.9	7.4	7.7	0.9	5.0	9.1
	Il-76-M_FRT_D-30-KP-2	12.7		0.2%	15.2	8.9	2.7	8.7	5.6	0.9	1.7	10.1
	T20_Blank-Blank	2.7		0.0%	22.8	10.2	0.2	10.0	1.5	0.0	0.3	2.2

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	9-13 km Altitude Band EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
Turboprops		**8,787.6**	**2.5%**		**11.9**	**3.8**	**0.2**				**7,416.3**	
	SF3_MDTURB	1,266.2		14.41%	12.5	4.4	0.5				1,074.6	
	DH8_MDTURB	960.1		10.93%	12.8	4.3	0.6				802.0	
	ATR_LGTURB	797.2		9.07%	14.2	3.8	0.0				679.4	
	BE1_SMTURB	755.9		8.60%	8.8	3.1	0.1				645.3	
	EM2_SMTURB	721.8		8.21%	8.8	3.0	0.1				618.9	
	AT7_LGTURB	529.3		6.02%	14.2	3.7	0.0				443.3	
	F50_LGTURB	527.5		6.00%	14.2	3.8	0.0				450.8	
	J31_SMTURB	358.0		4.07%	8.8	3.0	0.1				295.7	
	DH1_MDTURB	326.4		3.71%	12.5	4.4	0.5				271.6	
	SWM_SMTURB	289.4		3.29%	8.7	3.1	0.1				252.6	
	J41_MDTURB	282.6		3.22%	12.2	4.5	0.5				244.9	
	D38_MDTURB	267.9		3.05%	11.6	4.6	0.5				241.2	
	S20_LGTURB	238.7		2.72%	13.7	3.8	0.0				212.2	
	DH3_MDTURB	217.1		2.47%	12.5	4.4	0.5				186.3	
	AT4_LGTURB	187.8		2.14%	14.1	3.8	0.0				160.3	
	DHT_SMTURB	176.1		2.00%	8.9	3.0	0.1				113.9	
	ATP_LGTURB	111.7		1.27%	14.4	3.6	0.0				90.3	
	SH6_MDTURB	95.7		1.09%	13.8	3.9	0.5				70.3	
	EMB_SMTURB	94.2		1.07%	8.9	3.0	0.1				73.0	
	F27_LGTURB	91.1		1.04%	14.1	3.8	0.0				75.5	
	AN4_LGTURB	88.1		1.00%	13.6	3.9	0.0				79.2	
	BEH_SMTURB	73.2		0.83%	8.7	3.1	0.1				61.3	
	DH7_LGTURB	52.8		0.60%	14.4	3.7	0.0				43.0	
	D28_SMTURB	49.9		0.57%	8.9	3.0	0.1				37.2	
	HS7_LGTURB	46.8		0.53%	13.9	3.8	0.0				40.5	
	YS1_LGTURB	37.5		0.43%	14.2	3.6	0.0				29.0	
	BE9_SMTURB	30.8		0.35%	8.7	3.2	0.1				27.4	
	YN7_LGTURB	25.3		0.29%	14.0	3.9	0.0				22.5	

Appendix D – Effective Global Emissions Indices for 1999 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	1-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (1-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
Turboprops (Continued)												
	L4T_SMTURB	24.8		0.28%	8.8	3.0	0.1				19.6	
	BES_SMTURB	9.8		0.11%	8.7	2.8	0.1				8.5	
	CVF_LGTURB	9.0		0.10%	13.9	3.9	0.0				7.9	
	LOF_LGTURB	8.1		0.09%	13.3	3.7	0.0				7.8	
	ANF_MDTURB	6.1		0.07%	11.0	4.2	0.2				5.7	
	LOM_LGTURB	5.6		0.06%	13.3	3.9	0.0				5.1	
	SH3_MDTURB	5.6		0.06%	13.2	4.2	0.5				4.5	
	IL8_LGTURB	3.8		0.04%	13.3	3.8	0.0				3.5	
	AN6_MDTURB	3.7		0.04%	11.2	4.7	0.4				3.4	
	CS5_LGTURB	3.5		0.04%	13.0	3.5	0.0				2.4	
	CNC_SMTURB	2.2		0.03%	9.1	2.5	0.1				1.2	
	SHS_SMTURB	2.0		0.02%	8.9	3.0	0.1				1.5	
	ND2_MDTURB	1.9		0.02%	14.9	3.4	0.3				1.3	
	LOH_LGTURB	1.4		0.02%	13.6	3.8	0.0				1.2	
	CV5_LGTURB	0.7		0.01%	14.9	3.6	0.0				0.6	

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Airbus A300-600		**1,012,579**	**1.4%**	**825**	**1.2%**	**1,228**
	A300-620R_PW4000-4158	438,116	43.3%	474	57.5%	925
	A300-600R_CF6-80C2A5	403,445	39.8%	193	23.4%	2,092
	A300-600_CF6-80C2A3	68,224	6.7%	63	7.6%	1,085
	A300-620_JT9D-7R4H1	41,405	4.1%	58	7.0%	719
	A300-600_FRT_CF6-80C2A5F	41,086	4.1%	28	3.4%	1,453
	A300-620_PW4000-4158	10,803	1.1%	6	0.7%	1,801
	A300-600R_CF6-80C2A5F	9,499	0.9%	3	0.4%	2,771
Airbus A300-B2/B4/F4		**273,690**	**0.4%**	**199**	**0.3%**	**1,377**
	A300-B4-200_CF6-50C2	88,165	32.2%	56	28.3%	1,570
	A300-B2-100_CF6-50C	41,704	15.2%	35	17.5%	1,201
	A300-B4-120_JT9D-59A	33,972	12.4%	20	10.3%	1,663
	A300-B2-200_CF6-50C2R	30,132	11.0%	24	12.2%	1,248
	A300-B2-200FF_CF6-50C2	20,841	7.6%	22	10.9%	960
	A300-B4-200F_FRT_CF6-50C2	19,140	7.0%	7	3.7%	2,627
	A300-B2-200_CF6-50C2	17,244	6.3%	24	12.1%	718
	A300-F4-200_FRT_CF6-50C2	16,552	6.1%	6	2.9%	2,897
	A300-B4-200FF_CF6-50C2	3,402	1.2%	2	1.2%	1,489
	A300-B4-100_CF6-50C2	2,539	0.9%	2	1.2%	1,111
Airbus A310		**1,044,357**	**1.5%**	**464**	**0.7%**	**2,251**
	A310-300_CF6-80C2A2	312,847	30.0%	146	31.5%	2,141
	A310-320_PW4000-4152	265,031	25.4%	109	23.6%	2,425
	A310-300_CF6-80C2A8	206,423	19.8%	71	15.2%	2,919
	A310-200_CF6-80A3	107,586	10.3%	59	12.8%	1,810
	A310-200_CF6-80C2A2	58,743	5.6%	30	6.5%	1,958
	A310-220_JT9D-7R4E1	36,845	3.5%	21	4.5%	1,755
	A310-320_PW4000-4156A	35,994	3.5%	14	3.1%	2,520
	A310-320_JT9D-7R4E1	20,889	2.0%	13	2.8%	1,589

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Airbus A319	**692,169**	**1.0%**	**537**	**0.8%**	**1,289**
A319-110_CFM56-5A4	232,750	33.6%	109	20.3%	2,138
A319-110_CFM56-5A5	193,924	28.0%	151	28.1%	1,288
A319-110_CFM56-5B5_P	94,740	13.7%	65	12.0%	1,467
A319-110_CFM56-5B6_2P	61,614	8.9%	56	10.5%	1,092
A319-110_CFM56-5B6_P	48,724	7.0%	86	16.0%	568
A319-130_V2500-2524-A5	35,150	5.1%	52	9.6%	682
A319-130_V2500-2522-A5	25,266	3.7%	19	3.5%	1,330
Airbus A320	**3,818,451**	**5.4%**	**3,071**	**4.4%**	**1,243**
A320-110_CFM56-5A1	1,824,134	47.8%	1,667	54.3%	1,094
A320-210_CFM56-5B4_P	673,556	17.6%	375	12.2%	1,798
A320-210_CFM56-5A1	653,329	17.1%	438	14.3%	1,490
A320-210_CFM56-5A3	253,641	6.6%	197	6.4%	1,285
A320-210_CFM56-5B4	117,499	3.1%	75	2.5%	1,561
A320-210_CFM56-5B4_2	95,698	2.5%	116	3.8%	823
A320-210_CFM56-5B4_2P	85,472	2.2%	82	2.7%	1,046
A320-230_V2500-2527E-A5	48,379	1.3%	49	1.6%	996
A320-230_V2500-2500-A1	37,428	1.0%	34	1.1%	1,110
A320-230_V2500-2527-A5	29,316	0.8%	38	1.2%	774
Airbus A321	**361,687**	**0.5%**	**448**	**0.6%**	**807**
A321-110_CFM56-5B2	111,007	30.7%	102	22.7%	1,093
A321-110_CFM56-5B1_2	71,275	19.7%	108	24.0%	662
A321-130_V2500-2530-A5	59,509	16.5%	67	14.9%	890
A321-210_CFM56-5B3_P	53,446	14.8%	62	13.7%	868
A321-210_CFM56-5B3_2P	53,269	14.7%	102	22.7%	524
A321-230_V2500-2533-A5	13,180	3.6%	9	2.0%	1,488

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Airbus A330-200	**138,796**	**0.2%**	**39**	**0.1%**	**3,572**
A330-220_PW4000-4168A	119,770	86.3%	34	88.2%	3,493
A330-240_Trent-772B-60	18,068	13.0%	4	11.0%	4,216
A330-200_CF6-80E1A4	958	0.7%	0	0.7%	3,353
Airbus A330-300	**510,219**	**0.7%**	**250**	**0.4%**	**2,044**
A330-320_PW4000-4168	152,881	30.0%	78	31.1%	1,971
A330-300_CF6-80E1A2	129,029	25.3%	47	18.7%	2,771
A330-340_Trent-772-60	112,357	22.0%	63	25.4%	1,775
A330-320_PW4000-4164	58,195	11.4%	46	18.3%	1,273
A330-340_Trent-768-60	57,757	11.3%	16	6.6%	3,516
Airbus A340-200	**140,216**	**0.2%**	**20**	**0.0%**	**6,961**
A340-210_CFM56-5C2	92,676	66.1%	13	64.5%	7,129
A340-210_CFM56-5C2G	26,794	19.1%	3	15.6%	8,525
A340-210_CFM56-5C3_F	20,746	14.8%	4	19.9%	5,186
Airbus A340-300	**1,250,423**	**1.8%**	**224**	**0.3%**	**5,589**
A340-310_CFM56-5C4	754,377	60.3%	144	64.6%	5,223
A340-310_CFM56-5C2	405,735	32.5%	55	24.8%	7,320
A340-310_CFM56-5C3_F	90,310	7.2%	24	10.7%	3,785

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
BAC111		**45,221**	**0.1%**	**57**	**0.1%**	**797**
	One-Eleven-500_Spey-512-14DW	27,964	61.8%	37	64.7%	762
	One-Eleven-560_Spey-512-14DW	17,257	38.2%	20	35.3%	863
BAE 146		**630,398**	**0.9%**	**993**	**1.4%**	**635**
	146-200_ALF502-R-5	415,062	65.8%	686	69.1%	605
	146-300_ALF502-R-5	114,367	18.1%	195	19.6%	587
	146-100_ALF502-R-5	53,409	8.5%	59	5.9%	910
	146-300_LF507-1H	41,890	6.7%	45	4.6%	922
	146-300QT_FRT_ALF502-R-5	5,670	0.9%	8	0.8%	709
Boeing 707		**105,766**	**0.2%**	**41**	**0.1%**	**2,607**
	707-320C_JT3D-3B	2,722	2.6%	2	4.9%	1,361
	707-320C_FRT_JT3D-7	13,664	12.9%	5	11.3%	2,989
	707-320C_FRT_JT3D-3B	84,458	79.9%	31	77.5%	2,687
	707-320C_All_FRT_JT3D-3B	4,922	4.7%	3	6.3%	1,914
Boeing 717		**0**	**0.0%**	**0**	**0.0%**	**0**

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Boeing 727-100		**205,915**	**0.3%**	**261**	**0.4%**	**789**
	727-100QF_FRT_RB.183-651-54	36,435	17.7%	50	19.2%	729
	727-100F_FRT_JT8D-9	2,123	1.0%	2	0.8%	991
	727-100F_FRT_JT8D-7B	41,525	20.2%	54	20.8%	765
	727-100C_JT8D-9	11,797	5.7%	8	3.2%	1,400
	727-100C_CMB_JT8D-7B	7,668	3.7%	5	2.0%	1,451
	727-100C_CMB_JT8D-7	1,491	0.7%	1	0.6%	1,044
	727-100_JT8D-9	3,087	1.5%	3	1.1%	1,080
	727-100_JT8D-7B	86,090	41.8%	112	42.9%	769
	727-100_JT8D-7	15,700	7.6%	25	9.5%	635
Boeing 727-200		**2,532,550**	**3.6%**	**2,353**	**3.4%**	**1,077**
	727-200_JT8D-15	1,443,421	57.0%	1,403	59.7%	1,029
	727-200_JT8D-9A	449,984	17.8%	360	15.3%	1,248
	727-200_JT8D-17R	279,982	11.1%	235	10.0%	1,190
	727-200F_FRT_JT8D-9	91,148	3.6%	92	3.9%	986
	727-200_JT8D-9	84,997	3.4%	116	4.9%	734
	727-200F_FRT_JT8D-15	51,931	2.1%	42	1.8%	1,236
	727-200F_FRT_JT8D-7	49,592	2.0%	42	1.8%	1,185
	727-200_JT8D-17	32,169	1.3%	28	1.2%	1,143
	727-200F_FRT_JT8D-17R	22,337	0.9%	19	0.8%	1,158
	727-200_JT8D-7B	20,257	0.8%	10	0.4%	2,085
	727-200F_FRT_JT8D-17	6,733	0.3%	4	0.2%	1,625

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Boeing 737-100/200	**3,176,590**	**4.5%**	**4,013**	**5.8%**	**792**
737-200_JT8D-9A	1,215,577	38.3%	1,528	38.1%	796
737-200_JT8D-15	639,196	20.1%	844	21.0%	758
737-200_JT8D-15A	393,614	12.4%	552	13.8%	713
737-200_JT8D-17	311,240	9.8%	400	10.0%	778
737-200C_QC_JT8D-17A	302,133	9.5%	307	7.7%	984
737-200_JT8D-17A	185,907	5.9%	219	5.5%	850
737-200C_CMB_JT8D-17	47,616	1.5%	61	1.5%	786
737-200_JT8D-9	28,804	0.9%	36	0.9%	794
737-200C_JT8D-9A	10,874	0.3%	12	0.3%	928
737-200QC_FRT_JT8D-9A	7,622	0.2%	8	0.2%	1,007
737-200C_JT8D-15	6,896	0.2%	15	0.4%	473
737-200C_JT8D-17	5,456	0.2%	8	0.2%	682
737-200C_JT8D-17A	5,350	0.2%	10	0.2%	559
737-200C_QC_JT8D-15A	4,781	0.2%	2	0.1%	2,092
737-200QC_FRT_JT8D-15	3,463	0.1%	2	0.1%	1,865
737-200C_QC_JT8D-9	3,280	0.1%	5	0.1%	717
737-200C_CMB_JT8D-9A	2,875	0.1%	4	0.1%	719
737-200_JT8D-7	1,218	0.0%	2	0.1%	609
737-200C_QC_JT8D-15	688	0.0%	1	0.0%	963
Boeing 737-300/400/500	**9,147,802**	**13.0%**	**10,224**	**14.7%**	**895**
737-300_CFM56-3B1	4,200,235	45.9%	4,671	45.7%	899
737-400_CFM56-3C1	1,769,552	19.3%	1,932	18.9%	916
737-500_CFM56-3C1	1,006,448	11.0%	1,304	12.8%	772
737-500_CFM56-3B1	662,492	7.2%	728	7.1%	911
737-300_CFM56-3C1	646,331	7.1%	708	6.9%	913
737-300_CFM56-3B2	580,178	6.3%	593	5.8%	978
737-400_CFM56-3B2	279,567	3.1%	282	2.8%	991
737-300QC_QC_CFM56-3C1	2,998	0.0%	6	0.1%	477

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Boeing 737-600/700/800	**1,047,151**	**1.5%**	**771**	**1.1%**	**1,357**
737-800_CFM56-7B26	418,237	39.9%	260	33.7%	1,611
737-700_CFM56-7B22	281,044	26.8%	208	26.9%	1,352
737-700_CFM56-7B24	274,064	26.2%	203	26.3%	1,351
737-600_CFM56-7B20	62,655	6.0%	97	12.5%	648
737-800_CFM56-7B24	11,150	1.1%	4	0.6%	2,518
Boeing 747-100/200/300	**2,573,174**	**3.7%**	**570**	**0.8%**	**4,517**
747-200B_JT9D-7Q	410,087	15.9%	75	13.2%	5,447
747-200SF_FRT_CF6-50E2	289,007	11.2%	64	11.2%	4,516
747-200F_FRT_CF6-50E2	244,817	9.5%	54	9.4%	4,570
747-200F_FRT_JT9D-7Q	220,206	8.6%	51	8.9%	4,354
747-100F_FRT_JT9D-7A	150,102	5.8%	43	7.6%	3,491
747-300_RB211-524D4	124,189	4.8%	27	4.7%	4,600
747-200B_CMB_CF6-50E2	115,260	4.5%	16	2.9%	7,016
747-200B_CF6-50E2	92,295	3.6%	15	2.6%	6,212
747-300_JT9D-7R4G2	89,993	3.5%	17	2.9%	5,431
747-200B_JT9D-7J	80,322	3.1%	22	3.9%	3,627
747-300_CF6-50E2	75,833	3.0%	11	2.0%	6,806
747-200F_FRT_JT9D-7J	65,191	2.5%	16	2.8%	4,038
747-100_JT9D-7A	65,143	2.5%	17	3.0%	3,832
747-200B_RB211-524D4	61,008	2.4%	12	2.1%	5,024
747-300_CF6-80C2B1	56,156	2.2%	8	1.4%	6,896
747-200F_FRT_RB211-524D4	51,559	2.0%	13	2.3%	4,010
747-200B_JT9D-7R4G2	48,806	1.9%	7	1.3%	6,570
747-200B_JT9D-7A	39,446	1.5%	12	2.1%	3,327
747-100_JT9D-7	33,445	1.3%	6	1.0%	5,853
747-200SF_FRT_RB211-524D4	28,566	1.1%	6	1.1%	4,444
747-SP_RB211-524D4	25,712	1.0%	6	1.0%	4,500
747-300_CMB_CF6-50E2	25,654	1.0%	6	1.1%	4,081

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Boeing 747-100/200/300 (Continued)					
747-300_CMB_JT9D-7R4G2	22,234	0.9%	4	0.7%	5,986
747-SP_JT9D-7F	19,752	0.8%	6	1.1%	3,142
747-200C_F_FRT_CF6-50E2	15,744	0.6%	4	0.8%	3,674
747-100B_SR_JT9D-7A	14,599	0.6%	16	2.8%	912
747-200SF_FRT_JT9D-7J	12,610	0.5%	3	0.5%	4,203
747-300_RB211-524C2	12,268	0.5%	8	1.5%	1,481
747-100B_RB211-524C2	12,124	0.5%	3	0.6%	3,536
747-SP_JT9D-7J	10,410	0.4%	5	0.9%	2,082
747-200F_FRT_JT9D-7R4G2	9,739	0.4%	2	0.4%	4,010
747-SP_JT9D-7FW	8,388	0.3%	2	0.4%	4,194
747-200B_CMB_CF6-50E	7,756	0.3%	2	0.3%	4,176
747-200B_JT9D-7Q3	6,956	0.3%	1	0.2%	8,115
747-SR-100B_CF6-45A2	6,465	0.3%	1	0.2%	6,465
747-200B_CMB_JT9D-7Q	6,128	0.2%	2	0.4%	2,860
747-SP_JT9D-7A	4,929	0.2%	3	0.5%	1,917
747-200C_QC_CF6-50E2	4,500	0.2%	1	0.1%	7,876
747-200B_JT9D-7F	2,328	0.1%	1	0.1%	4,074
747-300_CMB_CF6-80C2B1	2,152	0.1%	1	0.2%	2,511
747-200B_JT9D-70A	1,293	0.1%	1	0.1%	2,262

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Boeing 747-400	**5,664,264**	**8.1%**	**1,006**	**1.4%**	**5,632**
747-400_CF6-80C2B1F	1,924,604	34.0%	398	39.6%	4,830
747-400_PW4000-4056	1,474,135	26.0%	246	24.5%	5,982
747-400_RB211-524H2	1,072,744	18.9%	158	15.7%	6,783
747-400_CMB_CF6-80C2B1F	601,789	10.6%	102	10.2%	5,883
747-400_RB211-524G	242,152	4.3%	32	3.2%	7,567
747-400F_FRT_PW4000-4056	125,433	2.2%	25	2.5%	4,933
747-400_CMB_PW4000-4056	118,220	2.1%	24	2.4%	4,897
747-400F_FRT_CF6-80C2B1F	79,428	1.4%	14	1.4%	5,673
747-400F_FRT_RB211-524H2	25,760	0.5%	5	0.5%	5,304
Boeing 757-200	**4,828,701**	**6.9%**	**2,741**	**3.9%**	**1,762**
757-200_PW2000-2037	2,130,837	44.1%	1,241	45.3%	1,717
757-200_RB211-535E4B	1,051,066	21.8%	405	14.8%	2,593
757-200_RB211-535E4	977,170	20.2%	562	20.5%	1,740
757-200_PW2000-2040	264,613	5.5%	134	4.9%	1,968
757-200PF_FRT_RB211-535E4	217,355	4.5%	174	6.4%	1,249
757-200_RB211-535C	177,641	3.7%	222	8.1%	799
757-200PF_FRT_PW2000-2040	10,018	0.2%	3	0.1%	3,896

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Boeing 767-200		**1,417,564**	**2.0%**	**492**	**0.7%**	**2,884**
	767-200_JT9D-7R4D	373,990	26.4%	119	24.2%	3,150
	767-200ER_CF6-80A	267,474	18.9%	61	12.5%	4,354
	767-200ER_CF6-80C2B2	173,046	12.2%	39	7.9%	4,470
	767-200_CF6-80A	118,609	8.4%	110	22.4%	1,077
	767-200EM_JT9D-7R4D	114,484	8.1%	23	4.7%	4,978
	767-200ER_PW4000-4056	67,773	4.8%	12	2.4%	5,785
	767-200ER_CF6-80C2B4	59,372	4.2%	10	2.0%	6,023
	767-200ER_JT9D-7R4E	51,047	3.6%	48	9.9%	1,054
	767-200ER_JT9D-7R4E4	51,015	3.6%	26	5.4%	1,930
	767-200ERM_JT9D-7R4E	39,616	2.8%	12	2.4%	3,424
	767-200_CF6-80C2B2F	32,646	2.3%	16	3.2%	2,059
	767-200EM_CF6-80A2	24,814	1.8%	4	0.8%	6,203
	767-200PC_FRT_CF6-80A	23,122	1.6%	9	1.8%	2,611
	767-200ER_CF6-80C2B4F	20,559	1.5%	3	0.6%	7,196
Boeing 767-300		**4,043,356**	**5.8%**	**1,533**	**2.2%**	**2,638**
	767-300ER_PW4000-4060	1,686,367	41.7%	477	31.1%	3,536
	767-300ER_CF6-80C2B6	809,403	20.0%	191	12.4%	4,244
	767-300ER_CF6-80C2B6F	496,144	12.3%	124	8.1%	3,997
	767-300_CF6-80C2B2	279,758	6.9%	312	20.4%	896
	767-300ER_RB211-524H3	166,978	4.1%	99	6.4%	1,694
	767-300ERF_FRT_CF6-80C2B6F	123,009	3.0%	60	3.9%	2,050
	767-300ER_CF6-80C2B4	111,343	2.8%	42	2.8%	2,633
	767-300_JT9D-7R4D	92,559	2.3%	101	6.6%	918
	767-300ER_PW4000-4056	69,406	1.7%	22	1.5%	3,095
	767-300_CF6-80C2B2F	60,661	1.5%	49	3.2%	1,242
	767-300ER_CF6-80C2B7F	43,500	1.1%	11	0.7%	3,854
	767-300ER_CF6-80C2B2	42,449	1.1%	12	0.8%	3,496

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Boeing 767-300 (Continued)					
767-300ER_PW4000-4062	19,138	0.5%	5	0.4%	3,525
767-300ER_RB211-524H2	15,996	0.4%	9	0.6%	1,750
767-300_CF6-80C2B4F	8,989	0.2%	7	0.5%	1,284
767-300_PW4000-4056	8,950	0.2%	8	0.5%	1,119
767-300ERF_FRT_CF6-80C2B7F	8,706	0.2%	3	0.2%	2,902
Boeing 777-200	**1,583,564**	**2.3%**	**473**	**0.7%**	**3,345**
777-200ER_PW4000-4090	452,251	28.6%	93	19.7%	4,848
777-200ER_GE90-92B	371,319	23.5%	112	23.6%	3,324
777-200ER_Trent-892	290,345	18.3%	60	12.8%	4,805
777-200ER_GE90-85B	204,362	12.9%	42	8.8%	4,899
777-200ER_Trent-884	94,872	6.0%	27	5.6%	3,551
777-200_PW4000-4074	80,207	5.1%	80	16.9%	1,004
777-200_Trent-875	49,713	3.1%	27	5.6%	1,871
777-200_PW4000-4077	40,495	2.6%	33	7.0%	1,222
Boeing 777-300	**131,672**	**0.2%**	**82**	**0.1%**	**1,614**
777-300_Trent-892	93,513	71.0%	38	46.1%	2,489
777-300_PW4000-4090	38,160	29.0%	44	53.9%	867

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
DC-10		**1,523,344**	**2.2%**	**379**	**0.5%**	**4,022**
	DC-10-30_CF6-50C2	570,817	37.5%	110	29.1%	5,183
	DC-10-40_JT9D-20	312,347	20.5%	79	20.8%	3,968
	DC-10-10_CF6-6K	160,953	10.6%	40	10.6%	3,995
	DC-10-30_CF6-50C	112,142	7.4%	31	8.2%	3,634
	DC-10-10F_FRT_CF6-6D	84,340	5.5%	32	8.4%	2,659
	DC-10-10_CF6-6D	74,985	4.9%	27	7.2%	2,763
	DC-10-30CF_CF6-50C2	65,741	4.3%	17	4.5%	3,900
	DC-10-40I_JT9D-59A	65,671	4.3%	28	7.3%	2,382
	DC-10-30F_FRT_CF6-50C2	61,993	4.1%	13	3.6%	4,616
	DC-10-30_CF6-50C2R	12,227	0.8%	2	0.5%	7,133
	DC-10-30_CF6-50C1	2,126	0.1%	0	0.1%	7,440
DC-8		**451,733**	**0.6%**	**266**	**0.4%**	**1,699**
	DC-8-71F_FRT_CFM56-2C1	182,142	40.3%	107	40.2%	1,705
	DC-8-73CF_FRT_CFM56-2C1	90,719	20.1%	62	23.2%	1,473
	DC-8-63_FRT_JT3D-7	82,442	18.3%	51	19.1%	1,621
	DC-8-73F_FRT_CFM56-2C1	31,639	7.0%	11	4.3%	2,803
	DC-8-61C_FRT_JT3D-3B	21,294	4.7%	13	5.1%	1,586
	DC-8-54CF_FRT_JT3D-3B	19,964	4.4%	13	4.7%	1,588
	DC-8-63CF_FRT_JT3D-7	14,112	3.1%	6	2.4%	2,195
	DC-8-62CF_FRT_JT3D-3B	9,420	2.1%	3	1.1%	3,297

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
DC-9		**2,379,550**	**3.4%**	**3,346**	**4.8%**	**711**
	DC-9-31_JT8D-7B	669,058	28.1%	965	28.9%	693
	DC-9-32_JT8D-9A	472,957	19.9%	557	16.7%	849
	DC-9-31_JT8D-9A	328,957	13.8%	530	15.8%	621
	DC-9-51_JT8D-17	232,402	9.8%	441	13.2%	526
	DC-9-41_FRT_JT8D-11	132,692	5.6%	167	5.0%	796
	DC-9-15_JT8D-7A	110,330	4.6%	121	3.6%	915
	DC-9-41_JT8D-11	73,398	3.1%	113	3.4%	651
	DC-9-32_JT8D-7A	70,219	3.0%	84	2.5%	836
	DC-9-32_JT8D-7B	67,205	2.8%	92	2.7%	734
	DC-9-32_JT8D-17	57,120	2.4%	66	2.0%	865
	DC-9-31_JT8D-7A	51,878	2.2%	44	1.3%	1,171
	DC-9-51_JT8D-17A	32,469	1.4%	62	1.9%	522
	DC-9-21_JT8D-11	18,449	0.8%	21	0.6%	879
	DC-9-41_JT8D-15	16,761	0.7%	18	0.5%	924
	DC-9-15_JT8D-7	13,024	0.6%	20	0.6%	651
	DC-9-32_JT8D-11	10,691	0.5%	15	0.5%	693
	DC-9-32_JT8D-9	8,819	0.4%	15	0.5%	588
	DC-9-31CF_JT8D-17	6,950	0.3%	6	0.2%	1,081
	DC-9-15RC_FRT_JT8D-7B	3,126	0.1%	4	0.1%	729
	DC-9-33CF_JT8D-9A	3,045	0.1%	4	0.1%	688
Fokker 100		**1,079,091**	**1.5%**	**1,697**	**2.4%**	**636**
	100-*_RB.183-650-15	963,270	89.3%	1,499	88.4%	643
	100-*_RB.183-620-15	115,820	10.7%	198	11.6%	586

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Fokker 28		**358,254**	**0.5%**	**626**		**572**
	F.28-4000_Spey-555-15P	299,518	83.6%	495	79.0%	605
	F.28-1000_Spey-555-15	29,868	8.3%	69	11.0%	434
	F.28-3000_Spey-555-15H	15,862	4.4%	23	3.6%	698
	F.28-2000_Spey-555-15	10,042	2.8%	29	4.6%	348
	F.28-4000_Spey-555-15H	2,964	0.8%	11	1.7%	273
Fokker 70		**149,699**	**0.2%**	**198**	**0.3%**	**756**
	70-*_RB.183-620-15	149,699	100.0%	198	100.0%	756
Lockheed L-1011		**288,761**	**0.4%**	**140**		**2,058**
	L-1011-1_RB211-22B	197,439	68.4%	106	75.8%	1,858
	L-1011-500_RB211-524B4	60,864	21.1%	22	15.5%	2,803
	L-1011-200_FRT_RB211-524B	13,561	4.7%	6	4.1%	2,373
	L-1011-50_RB211-22B	13,309	4.6%	5	3.4%	2,823
	L-1011-200_FRT_RB211-524B4	2,647	0.9%	2	1.1%	1,685
	L11_Blank-Blank	940	0.3%	0	0.2%	3,289
MD-11		**1,541,979**	**2.2%**	**308**	**0.4%**	**5,006**
	MD-11-Passenger_CF6-80C2D1F	555,776	36.0%	105	34.2%	5,279
	MD-11-Freighter_FRT_CF6-80C2D1F	337,791	21.9%	82	26.5%	4,141
	MD-11-Passenger_PW4000-4460	317,609	20.6%	66	21.5%	4,792

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic Type	OAG Airplane/Engine	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
MD-11 (Continued)						
	MD-11-Passenger_PW4000-4462	224,607	14.6%	38	12.2%	5,955
	MD-11-Combi_CMB_CF6-80C2D1F	59,034	3.8%	8	2.6%	7,513
	MD-11-Freighter_FRT_PW4000-4460	37,810	2.5%	8	2.5%	4,994
	MD-11-CF_QC_PW4000-4460	4,701	0.3%	1	0.4%	4,114
	MD-11-CF_QC_PW4000-4462	4,651	0.3%	1	0.2%	8,139
MD-80		**5,619,233**	**8.0%**	**5,397**	**7.7%**	**1,041**
	MD-80-82_JT8D-217C	2,223,295	39.6%	1,907	35.3%	1,166
	MD-80-83_JT8D-219	1,284,164	22.9%	1,174	21.8%	1,094
	MD-80-88_JT8D-219	918,618	16.4%	1,008	18.7%	912
	MD-80-82_JT8D-217A	478,447	8.5%	426	7.9%	1,123
	MD-80-87_JT8D-217C	207,137	3.7%	234	4.3%	887
	MD-80-81_JT8D-217C	199,394	3.6%	338	6.3%	590
	MD-80-81_JT8D-217	163,056	2.9%	171	3.2%	954
	MD-80-82_JT8D-217	91,286	1.6%	75	1.4%	1,213
	MD-80-87_JT8D-219	46,861	0.8%	50	0.9%	937
	MD-80-83_JT8D-217C	6,976	0.1%	15	0.3%	461
MD-90		**331,624**	**0.5%**	**442**	**0.6%**	**750**
	MD-90-30_V2500-2528-D5	168,019	50.7%	188	42.4%	895
	MD-90-30_V2500-2525-D5	163,605	49.3%	255	57.6%	643
Miscellaneous		**3,013**	**0.00%**	**5**	**0.01%**	**659**
	DFL_Blank-Blank	2,146	71.2%	3	68.8%	683
	LRJ_Blank-Blank	866	28.8%	1	31.3%	606

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Regional Jets	**2,096,416**	**3.0%**	**3,198**	**4.6%**	**656**
CRJ-100ER_CF34-3A1	931,379	44.4%	1,417	44.3%	657
EMJ_Blank-Blank	309,117	14.8%	465	14.5%	665
RJ-RJ85_LF507-1F	258,052	12.3%	434	13.6%	595
CRJ-100LR_CF34-3A1	151,954	7.3%	202	6.3%	752
CRJ-200LR_CF34-3B1	123,117	5.9%	166	5.2%	740
RJ-RJ100_LF507-1F	97,273	4.6%	162	5.1%	600
ERJ-145-ER_AE-A	73,519	3.5%	145	4.5%	509
CRJ-200ER_CF34-3B1	52,196	2.5%	73	2.3%	711
RJ-RJ70_LF507-1F	45,163	2.2%	61	1.9%	746
ERJ-145-EP_AE-A	37,098	1.8%	48	1.5%	775
ERJ-145-EP_AE-A1_1	13,370	0.6%	19	0.6%	688
ERJ-145-LR_AE-A1	4,178	0.2%	6	0.2%	665
Russian Aircraft	**1,266,310**	**1.8%**	**701**	**1.0%**	**1,806**
Tu-154-B_NK-8-2U	375,774	29.7%	192	27.4%	1,959
Il-62-M_D-30-KU	199,657	15.8%	37	5.3%	5,334
Tu-154-M_D-30-KU-154-II	192,131	15.2%	115	16.5%	1,665
Tu-134-A_D-30-3	161,969	12.8%	129	18.4%	1,253
Il-86-*_NK-86	80,838	6.4%	33	4.7%	2,482
Il-76-T_FRT_D-30-KP-2	55,117	4.4%	20	2.8%	2,776
Tu-134-A_D-30-2	42,909	3.4%	37	5.2%	1,173
Il-96-300_PS-90-A	29,432	2.3%	5	0.7%	6,438
Yak-42-*_D-36	25,717	2.0%	23	3.3%	1,111
Yak-40-*_AI-25	25,391	2.0%	41	5.9%	615
Yak-42-D_D-36	18,436	1.5%	19	2.7%	993

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Russian Aircraft (Continued)					
Yak-40-*_AI-25-Blank	15,018	1.2%	29	4.1%	523
Yak-42-*_D-36-Blank	14,974	1.2%	11	1.5%	1,417
Il-62-*_NK-8-4	9,968	0.8%	3	0.4%	3,489
Il-86-*_NK-86-Blank	6,107	0.5%	2	0.2%	3,563
An-124-*_FRT_D-18-T	5,416	0.4%	2	0.2%	3,446
Tu-134-B_D-30-3	4,882	0.4%	4	0.6%	1,178
Il-76-M_FRT_D-30-KP-2	1,878	0.2%	1	0.1%	3,287
T20_Blank-Blank	695	0.1%	0	0.0%	2,433
Concorde	**33,890**	**0.05%**	**6**	**0.01%**	**5,648**
concorde_05_1999	33,890	100.0%	6	100.0%	5,648
Turboprops	**6,608,584**	**9.4%**	**21,296**	**30.6%**	**310**
SF3_MDTURB	935,252	14.2%	2,688	12.6%	348
DH8_MDTURB	685,694	10.4%	2,270	10.7%	302
BE1_SMTURB	650,725	9.9%	2,247	10.6%	290
EM2_SMTURB	633,128	9.6%	1,927	9.1%	329
ATR_LGTURB	538,681	8.2%	1,610	7.6%	335
AT7_LGTURB	355,585	5.4%	1,097	5.2%	324
F50_LGTURB	355,384	5.4%	1,078	5.1%	330
J31_SMTURB	304,815	4.6%	1,127	5.3%	270
SWM_SMTURB	253,832	3.8%	761	3.6%	333
DH1_MDTURB	238,445	3.6%	753	3.5%	317
D38_MDTURB	215,605	3.3%	424	2.0%	508
J41_MDTURB	215,009	3.3%	531	2.5%	405

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Turboprops (Continued)					
S20_LGTURB	173,530	2.6%	333	1.6%	522
DH3_MDTURB	158,280	2.4%	492	2.3%	322
DHT_SMTURB	129,414	2.0%	1,080	5.1%	120
AT4_LGTURB	125,453	1.9%	407	1.9%	308
EMB_SMTURB	76,313	1.2%	384	1.8%	199
ATP_LGTURB	71,950	1.1%	285	1.3%	252
AN4_LGTURB	64,815	1.0%	116	0.5%	559
BEH_SMTURB	63,492	1.0%	216	1.0%	294
F27_LGTURB	61,075	0.9%	205	1.0%	298
SH6_MDTURB	59,446	0.9%	345	1.6%	172
D28_SMTURB	40,021	0.6%	216	1.0%	186
DH7_LGTURB	34,387	0.5%	127	0.6%	272
HS7_LGTURB	31,414	0.5%	100	0.5%	315
BE9_SMTURB	26,645	0.4%	89	0.4%	301
YS1_LGTURB	23,575	0.4%	113	0.5%	209
L4T_SMTURB	20,111	0.3%	103	0.5%	194
YN7_LGTURB	17,525	0.3%	43	0.2%	404
BES_SMTURB	8,784	0.1%	21	0.1%	410
LOF_LGTURB	6,600	0.1%	4	0.0%	1,711
CVF_LGTURB	6,304	0.1%	16	0.1%	394

Appendix E – Departure and Distance Summaries for May 1999 Scheduled Air Traffic

Generic OAG Airplane/Engine Type	Distance (km/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (km)
Turboprops (Continued)					
ANF_MDTURB	5,469	0.1%	5	0.0%	1,196
LOM_LGTURB	4,310	0.1%	6	0.0%	774
SH3_MDTURB	3,755	0.1%	16	0.1%	239
AN6_MDTURB	3,154	0.1%	5	0.0%	649
IL8_LGTURB	2,944	0.0%	3	0.0%	859
CS5_LGTURB	2,100	0.0%	15	0.1%	139
SHS_SMTURB	1,593	0.0%	9	0.0%	186
CNC_SMTURB	1,488	0.0%	18	0.1%	85
ND2_MDTURB	1,044	0.0%	9	0.0%	112
LOH_LGTURB	994	0.0%	2	0.0%	435
CV5_LGTURB	446	0.0%	1	0.0%	312

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13. ABSTRACT ***(Maximum 200 words)***

This report describes the development of a three-dimensional database of aircraft fuel burn and emissions (NOx, CO, and hydrocarbons) for the scheduled commercial aircraft fleet for each month of 1999. Global totals of emissions and fuel burn for 1999 are compared to global totals from 1992 and 2015 databases. 1999 fuel burn, departure and distance totals for selected airlines are compared to data reported on DOT Form 41 to evaluate the accuracy of the calculations. DOT Form T-100 data were used to determine typical payloads for freighter aircraft and this information was used to model freighter aircraft more accurately by using more realistic payloads. Differences in the calculation methodology used to create the 1999 fuel burn and emissions database from the methodology used in previous work are described and evaluated.

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